Pi Mu Epsilon

Pi Mu Epsilon is a national mathematics honor society with 359 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).

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.

Schedule of Student Activities

Unless otherwise noted, all events are held at the Monona Terrace

Please note that there are no MAA Sessions #18, or 22-26 and there are no PME Sessions #7-10.

Wednesday, August 1

Time:	Event:	Location:
2:00 pm - 4:00 pm	CUSAC Meeting	Hilton Madison Founders Room
4:30 pm - 5:30 pm	MAA/PME Student Reception	Hall of Ideas G/J
5:30 pm - 6:30 pm	Face Off!	Ballroom A

Thursday, August 2

Time:	Event:	Location:
8:30 am - 11:30 am	PME Council Meeting	Hall of Ideas E
8:30 am - 10:25 am	MAA Session #1	Meeting Room K
8:30 am - 10:25 am	MAA Session #2	Meeting Room L
8:30 am - 10:25 am	MAA Session #3	Meeting Room M
8:30 am - 10:25 am	MAA Session #4	Meeting Room N
8:30 am - 10:25 am	MAA Session #5	Meeting Room O
8:30 am - 10:25 am	MAA Session #6	Meeting Room P
9:00 am - 5:00 pm	Student Hospitality Center	Exhibit Hall B
1:00 pm - 1:50 pm	MAA Lecture for Students	Ballroom A
2:00 pm - 3:55 pm	MAA Session #7	Meeting Room K
2:00 pm - 3:55 pm	MAA Session #8	Meeting Room L
2:00 pm - 3:55 pm	MAA Session #9	Meeting Room M
2:00 pm - 3:55 pm	MAA Session #10	Meeting Room N
2:00 pm - 3:55 pm	PME Session #1	Meeting Room O
2:00 pm - 3:55 pm	PME Session #2	Meeting Room P
4:00 pm - 6:15 pm	MAA Session #11	Meeting Room K
4:00 pm - 6:15 pm	MAA Session #12	Meeting Room L
4:00 pm - 6:15 pm	MAA Session #13	Meeting Room M
4:00 pm - 6:15 pm	MAA Session #14	Meeting Room N
4:00 pm - 6:15 pm	PME Session #3	Meeting Room O
4:00 pm - 6:15 pm	PME Session #4	Meeting Room P

Friday, August 3

Time:	Event:	Location:
8:30 am - 11:45 am	MAA Session #15	Meeting Room K
8:30 am - 11:45 am	MAA Session #16	Meeting Room L
8:30 am - 11:45 am	MAA Session #17	Meeting Room M
8:30 am - 11:45 am	PME Session #5	Meeting Room O
8:30 am - 11:45 am	PME Session #6	Meeting Room P
9:00 am - 5:00 pm	Student Hospitality Center	Exhibit Hall B
1:00 pm - 1:50 pm	MAA Student Activities Session: Entertaining Math	Ballroom B
1:00 pm - 1:50 pm	MAA Student Activities Session: Mathematical Untuition	Ballroom C
2:00 pm - 3:55 pm	MAA Session #19	Meeting Room K
2:00 pm - 3:55 pm	MAA Session #20	Meeting Room L
2:00 pm - 3:55 pm	MAA Session #21	Meeting Room M
6:00 pm - 7:45 pm	PME Banquet and Awards Ceremony	Community Terrace
8:00 pm - 8:50 pm	J. Sutherland Frame Lecture	Ballroom AB
9:00 pm - 10:00 pm	MAA Ice Cream Social and Awards	Community Terrace

Saturday, August 4

Time:	Event:	Location:
9:00 am - 1:00 pm	Student Hospitality Center	Exhibit Hall B
9:00 am - 10:30 am	MAA Modeling (MCM) Winners	Hall of Ideas F
1:00 pm - 2:15 pm	Student Problem Solving Competition	Meeting Rooms K & L

J. Sutherland Frame Lecture

THE CHEMISTRY OF PRIMES

Melanie Matchett Wood
University of Wisconsin Madison

We are familiar with the prime numbers as those integers that cannot be factored into smaller integers, but if we consider systems of numbers larger than the integers, the primes may indeed factor in those larger systems. We discuss various questions mathematicians ask about how primes may factor in larger systems, talk about both classical results and current research on the topic, and give a sense of the kind of tools needed to tackle these questions.

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

GEOMETREKS

Ivars Peterson
Mathematical Association of America

Few people expect to encounter mathematics on a visit to an art gallery or even a walk down a city street (or across campus). When we explore the world around us with mathematics in mind, however, we see the many ways in which mathematics can manifest itself, in streetscapes, sculptures, paintings, architectural structures, and more. This illustrated presentation offers illuminating glimpses of mathematics, from Euclidean geometry and normal distributions to Riemann sums and Möbius strips, as seen in a variety of structures and artworks in Washington, D.C., Philadelphia, Toronto, Montreal, New Orleans, Madison, Wisconsin, and many other locales.

MAA Undergraduate Student Activities Sessions

ENTERTAINING MATH: JUGGLING, MAGIC AND CIRCUS TRICKS

Tim Chartier
Davidson College

Ballroom B

Love math but felt ever stuck on how to get someone else excited? How about juggling, presenting a magic trick, or performing a circus trick like balancing an object on your hand to teach or motivate a mathematical idea? This activity will explore ways to demonstrate and discuss mathematics using techniques generally associated with entertainment and the performing arts. Come ready to learn a few tricks and possibly some new math!

MATHEMATICAL UNTUITION - JUST HOW FAR ASTRAY CAN YOUR MATHEMATICAL COMMON SENSE MISLEAD YOU?

Brian Conrey
American Institute of Mathematics

Ballroom C

During this session we will discover some simple but truly surprising mathematical facts.

MAA Student Speakers

Name	School	MAA Session
Mike Agiorgousis	Ursinus College	17
Amir Y. Ahmadi	Morehead State University	1
Brandon Alberts	Michigan State University	20
Cory Ali	University of Houston - Downtown	15
Phil Ammirato	SUNY Stony Brook	5
Ryan Anderson	Kennesaw State University	21
Andrew Ardueser	Simpson College	16
Joshua Armstrong	University of Richmond	5
Kirstyn Baker	Alma College	3
Katrina Bandeli	Montclair State University	8
Vyassa Baratham	SUNY Stony Brook	10
Peter Barr	Wake Forest University	3
Erik Bates	Michigan State University	5
Crystal Bennett	North Carolina A&T State University	7
Rimi Bhowmik	University of St. Thomas	7
Philip John Bontrager	Goshen College	17
Ellen Borgeld	Grand Valley State University	16
Matthew Brems	Franklin College	4
Amanda Bright	Westminster College	8
Lindsey Brown	Baker University	17
Joseph Buchanan	Illinois State University	8
Jessica Burl	Clarkson University	15
Shelby Burnett	Cal Poly San Luis Obispo	2
Karleigh Cameron	Central Michigan University	5
Cara Cannon	Hope College	1
Michael Carlyle	Augustana College	8
Monica Lee Chalke	Bridgewater State University	2
Blake Chamberlain	Susquehanna University	5
Megan Chambers	Youngstown State University	17
Ashley Chandler	Cal Poly San Luis Obispo	2
Harini Chandramouli	University of Pittsburgh	9
Lindsay Christie	Clarkson University	7
Gregory James Clark	Westminster College	16
Courtney DeHoet	University of Tennessee at Martin	9
Chinae Edmonds	Central State University	10
Kristen Danielle Edwards	Central State University	10
Kaitlyn Eichinger	University of Kentucky	5

MAA Student Speakers (Continued)

Name	School	MAA Session
Michael Esch	Grand Valley State University	5
Joshua Fagan	University of Richmond	5
Nicole Fiorentino	Muhlenberg College	11
Michael Frank	Simpson College	15
Wes Galbraith	Hope College	3
Rachel Gettinger	Saint Vincent College	5
Whan Ghang	Massachusetts Institute of Technology	4
Caitlin Graff	Idaho State University	3
Anthony Graves-McCleary	Vassar College	3
Brian Green	Ursinus College	17
Hoang Ha	Bryn Mawr College	17
Spencer Havis	Benedictine University	15
Junnan He	Australian National University	17
Tyler J. Heaps	Augsburg College	9
Alexander M. Hegedus	Alma College	5
Miranda Henderson	Benedictine University	5
Andreana N. Holowatyj	Benedictine University	11
Weici Hu	Smith College	15
Katherine Hunzinger	Benedictine University	19
Joshua Jacobson	St. Olaf College	6
Michael Jun	University of California – Berkeley	6
Joshua Kalar	Clarkson University	1
Kingston Kang	Randolph-Macon College	20
Farina Kanwal	Benedictine University	19
Andrew Richard Kelly	Williams College	4
Pamela Kirkpatrick	Messiah College	11
Mark Kleehammer	SUNY Fredonia	13
Taylor Klotz	University of Colorado at Colorado Springs	14
Kirstin Ladas	University of Richmond	5
Gonzalo Landeros	Benedictine University	13
Julie Elizabeth Lang	Morehead State University	8
Andrew Lohr	University of Maryland	17
Samantha Longdaue	Clarkson University	1
Jeremy Mann	Johns Hopkins University	14
Ashley Martin	University of Tennessee at Martin	9
Zane Karas Martin	Williams College	4
Cristina Mata	SUNY Stony Brook	10
Gavin McGrew	University of Richmond	5
Sean Meehan	University of Notre Dame	16
Elizabeth Meena	Trinity Christian College	16

MAA Student Speakers (Continued)

Name	School	MAA Session
Camilo Montoya	Florida International University	21
Brandon Mosley	Westminster College	3
Michael Mudarri	Hood College	6
Kiran Munir	Benedictine University	19
James D. Munyon	Youngstown State University	17
Dat Pham Nguyen	SUNY Stony Brook	10
Jeffrey Nielsen	United States Military Academy	12
Yvette Niyomugaba	Southwestern University	1
Guy B. Oldaker	North Carolina A&T State University	1
Alex Onderdonk	Immaculata University	17
Lukas Owens	Whitman College	21
Shalin Parekh	SUNY Stony Brook	10
Margaret Peterson	College of Saint Benedict	21
Van Ngoc Thu Pham	Southwestern University	1
Natalia Poniatowska	Benedictine University	20
Denetra Lynette Porties	Central State University	10
Domonique Powell	Clarkson University	1
Angela Reddick	University of Tennessee at Martin	2
Brandon Reeves	Gonzaga University	9
Rachel Rice	Simpson College	16
Kim Rich	Bucknell University	17
Tanya Riston	Penn State Erie, The Behrend College	20
Benjamin Douglas Ritz	Clarkson University	7
Aaron Rodriguez	University of St. Thomas	7
Illian Rojas	University of Houston - Downtown	15
Rosa Romano	University of Richmond	5
Catherine Ross	Rose-Hulman Institute of Technology	5
Marissa Saladin	Aquinas College	5
Julian Salazar	Henry Wise Wood High School	16
Ted Samore	Rose-Hulman Institute of Technology	7
Mehak Sandhu	Benedictine University	13
Mark Schrecengost	Hope College	3
Alison G. Schuetz	Hood College	2
Amanda Schuiling	Hope College	15
Valentina M. Semenova	Dartmouth College	9
Tim Shaffer	Youngstown State University	6
Courtney Sherwood	Simpson College	15
Alexandra Signoriello	Ursinus College	11
Hope Snyder	Washington & Jefferson College	10
Ellen Sparks	Illinois State University	8
Aashish Srinivas	Swarthmore College	3
Nora Stack	St. Mary’s College of Maryland	9

MAA Student Speakers (Continued)

Name	School	MAA Session
Rita Vander Stad	William Paterson State University	5
Jack Stangl	University of St. Thomas	7
Karleen J. Stevens	Augsburg College	4
Benjamin Paul Studer	Augustana College	21
Samantha Tabackin	York College of Pennsylvania	16
Lindzey Brooke Thacker	Morehead State University	8
Philip Thomas	Indiana University	3
Lauren Tirado	Simpson College	15
Evan Tomkiewicz	Clarkson University	15
Jordan Torf	Illinois State University	16
Robert Vaughn	Hood College	2
Alicia Velek	York College of Pennsylvania	16
Alexander Wagner	Vanderbilt University	4
Emily Marie Walther	Westminster College	3
Steven Waruhiu	University of Chicago	4
Jakob Weisblat	Kent State University	6
Michael Weselcouch	Assumption College	16
Laura M. White	Arkansas State University	19
Peter Wiese	Augustana College	7
Melody Mone't Wilson	Central State University	10
Joshua Wilson	SUNY Potsdam/St. Olaf College	12
Kelly Woodard	Simpson College	16
Caleb J. Yonker	Grand Valley State University	5
Allison Zale	Illinois State University	3
Justin Ziegler	Minot State University	9

Pi Mu Epsilon Speakers

Name	School	Chapter	PME Session
Liliana Alvarez	Austin Peay State University	TN Epsilon	1
Ryan Arredondo	University of South Florida	FL Epsilon	5
Nick Benthem	Grand Valley State University	MI Iota	3
Beth Bjorkman	Grand Valley State University	MI Iota	6
Kristen Bosch	Hope College	MI Delta	4
Ashley Broadwell	Pepperdine University	CA Xi	6
Justin Brockmann	University of Wisconsin–Whitewater	WI Theta	4
Tyler Brown	Penn State Harrisburg	PA Phi	4
HanQin (Caesar) Cai	St. Norbert College	WI Delta	2
Nathaniel Card	Carthage College	WI Epsilon	3
Daniel P. Catello	Youngstown State University	OH Xi	5
Wilson Cheung	SUNY Geneseo	NY Alpha Delta	2
Marissa Clougher	Elmhurst College	IL Iota	4
Heather Cook	Roanoke College	VA Delta	3
Danielle M. DeChellis	Youngstown State University	OH Xi	6
Anne French	Austin Peay State University	TN Epsilon	3
Estee L. George	Youngstown State University	OH Xi	5
Preston Hardy	St. John's University	MN Delta	2
Sarah Heilig	New York University	NJ Epsilon	4
Kathleen Karika	Texas A&M University	TX Eta	5
Nathaniel Kell	Denison University	OH Iota	6
Heather Kitada	Lewis & Clark College	OR Eta	6
Luke Kressin	Hendrix College	AR Beta	6
Jacalyn Kulow	St Norbert College	WI Delta	5
Jeff LaJeunesse	St. Norbert College	WI Delta	5
Cory Medlin	Austin Peay State University	TN Epsilon	3
Marie Meyer	College of St. Benedict	MN Delta	6
Erik Miller	St. Norbert College	WI Delta	5
Tan Nguyen	University of Nevada – Las Vegas	NV Beta	2
Candice Nielsen	Elmhurst College	IL Iota	1
Matthew C. Pierson	Youngstown State University	OH Xi	6
Sarah Ritchey	Youngstown State University	OH Xi	1
Emily Sasala	Washington & Jefferson College	PA Omega	6

Pi Mu Epsilon Speakers (Continued)

Name	School	Chapter	PME Session
Ariel Setniker	Western Oregon University	OR Delta	1
Emarus Shay	Austin Peay State University	TN Epsilon	4
Bradley R. Slabe	Youngstown State University	OH Xi	1
Mario F. Sracic	Youngstown State University	OH Xi	5
Sarah Stiemke	St. Norbert College	WI Delta	2
Andrew Tew	University of Nebraska at Omaha	NE Gamma	1
Joshua Thornton	Pepperdine University	CA Xi	6
Sarah Wesley	Elmhurst College	IL Iota	4
Daniel White	Fordham University	NY Alpha Nu	2
Shane Wilson	Luther College	IA Beta	5
Frances Withrow	Texas A&M University	TX Eta	5
Timothy Yeatman	University of South Florida	FL Alpha	3

Delegates

Name	School	Chapter
Siddharth Dahiya	Penn State Harrisburg	PA Phi
Jennifer Hoxworth	Rowan University	NJ Xi
Stephanie Jessie	Austin Peay State University	TN Alpha
John-Pierre’ LaFleur	Southern University	LA Beta
Alayna McNamara	Rose-Hulman Institute of Technology	IN Gamma
Russell Pulvermacher	St. Norbert College	WI Delta
Jeremy Topolski	SUNY Fredonia	NY Pi

MAA Session #1

Room: Meeting Room K **8:30A.M. – 10:25A.M.**

8:30–8:45

Approximating a Hurricane's Path and Position Using Simplified Weather Models

Guy B. Oldaker

North Carolina A&T State University

Every year, the coasts of the U.S. are threatened by hurricanes. On the minds of many inhabitants is: "Where will the storm strike?" In this study we will explore how a hurricanes track can be approximated based on the observation data from NASA and apply some simple approaches to try and predict its future position. The goal of this project is to find the direct link between our daily weather phenomenon (e.g. hurricanes) and the differential equations (DEs) learned in regular classrooms. The considered models are the simplified underlying equations from the prediction models in our real weather forecasting systems. We will begin by solving, first a simple DE, and then a system of simple DEs, analytically and numerically, and comparing the results using Matlab programs. Next, we will interpolate a hurricanes path using its average velocity and compare it to the actual path. From there, we will move to two simplified weather models: one uses the observed pressure data and the other is a simple beta-advection model (BAM). Finally, we will present conclusions and some future improvements.

8:50–9:05

Mathematical Modeling the Growth and Spread of Marram Grass Populations in Vegetated Sand Dunes

Cara Cannon

Hope College

The presence or absence of plants critically affects the physical processes that shape and form vegetated sand dunes. This is due to the fact that roots impede erosion, while foliage promotes sand accumulation by slowing down the wind. Ammophila breviligulata (marram grass) thrives under conditions of moderate sand burial. This introduces interesting feedback dynamics, because the grass' presence impacts accumulation of sand, which, in turn, stimulates plant growth and spread. In this talk we will examine one side of this interaction by mathematically modeling marram grass population dynamics in the presence of sand burial. The model incorporates both local growth and spread through the use of integrodifference equations. Through model simulations we will address important questions relating to vegetated dune dynamics including whether population dynamics alone can lead to the formation of blowout sand dunes.

9:10–9:25

Phytoplankton Analysis in the St. Lawrence River

Samantha Longdaue, Domonique Powell, and Joshua Kalar
Clarkson University

Our major goal this summer is to model phytoplankton population in the St. Lawrence River. Due to prior research, our focus has narrowed down to phytoplankton interaction with vegetation fields, which include organisms that attach to plants and feed on the phytoplankton that pass by. These organisms are called grazers, and their consumption impacts the overall rate of phytoplankton growth/decay. Our objectives are to identify which factors have significant affects on the phytoplankton population, and quantify that affect. Moreover, we want to represent the activity in the water numerically using statistical methods, such as ANOVA testing or multiple linear regression, and dynamic mathematical models. Our resources have led us to hypothesize that rotifers, benthic grazers, and water grazers all affect phytoplankton population, causing it to decrease as the interaction with vegetation increases. In other words, the plant based grazers are eating the phytoplankton in the river.

9:30–9:45

Mathematical Models for Water Scarcity

Van Ngoc Thu Pham
Southwestern University

Water shortage has become one of global problems. Social and economic damage of water scarcity is greater in urban areas than other parts in a country due to a dense population concentration and higher water demand caused by city lifestyle. Mathematical models of population, water consumption, and precipitation will be presented.

9:50–10:05

Kentucky's Potential for Woody Biomass

Amir Y. Ahmadi
Morehead State University

The search for an economically efficient alternative to petroleum-based fuel products concerns many people. In the past, food-based biofuels generated controversy due to its exorbitant usage of food product. However, second generation biofuels—more specifically, woody biofuels, overcome the controversy and have the potential to yield greater quantity of usable products. Unfortunately, this production process has yet to be fully optimized.

This paper develops a numerical model for the simulation of wood pyrolysis biofuel production within a fluidized bed reactor. The results of this model are economically applied for a Kentucky wood species, Yellow Poplar, to estimate its current profitability. Conclusions shed light on short-term potential applications for the Kentucky wood market.

10:10–10:25

Recycling Toward a Better Earth Through Math

Yvette Niyomugaba
Southwestern University

As the world population increases significantly quickly, recycling is one of the effective ways to conserve and save energy and natural resources. In addition, recycling reduces landfill use and the environmental damage from pollutants and greenhouse gas emissions. Mathematical models of the production, consumption, and recycling of material will be presented.

MAA Session #2

Room: Meeting Room L **8:30A.M. – 10:25A.M.**

8:30–8:45

The Mandelbrot Set and Combinatorics of Real-valued Periodic Points

Alison G. Schuetz
Hood College

We studied the combinatorics of real-valued periodic points under iterated maps

$$f_c(z) = z^d + c.$$

For $d = 2$, the set of all parameters $c \in \mathbb{C}$ for which the orbit of 0 is bounded under these maps is known as the Mandelbrot set. For $d \geq 3$, these sets of parameters are called the Multibrot sets. For a given value $c \in \mathbb{C}$, the set of all $z \in \mathbb{C}$ for which the orbit is bounded is called the Julia set $\mathcal{J}_c$. We classify and count these real-valued periodic points for various d, as well as studying the H-compositions of the Julia sets which correspond to these real values.

To locate parameters $x \in \mathbb{C}$ which have periodic orbits, we compute the complex roots of polynomials $f_x^n(0)$. We examine these roots, and find partial recursion formulas for coefficients of the polynomial expansion of this $f_x^n(0)$. The polynomials generated when working with different periods of the Mandelbrot Set are each unique; however, we find patterns relating $f_x^n(0)$ with $f_x^{n-1}(0)$ and $f_x^{n+1}(0)$.

8:50–9:05

Around the Mandelbrot Set in 80 Days

Robert Vaughn
Hood College

The Mandelbrot set $\mathcal{M}$ is the subset of the complex plane corresponding to parameters $c \in \mathbb{C}$ such that the orbit of 0 under the map $f_c(z) = z^2 + c$ is bounded. Given a fixed parameter $c \in \mathcal{M}$, the filled Julia set $\mathcal{J}$ is the set of all points $z \in \mathbb{C}$ with bounded orbits under f_c. Points $c \in \mathcal{M}$ with period n correspond, via their orbit diagrams, with H-compositions of n. We give an algorithm to locate "bulbs" and "branches" in the Mandelbrot set corresponding to a fixed H-composition

$$n = a_1 + a_2 + ... + a_r.$$

In addition to mapping the patterns between points in $\mathcal{M}$ and orbital patterns in their Julia sets $\mathcal{J}$, we extend a known combinatorial formula for counting the number of periodic points in $\mathcal{M}$ to one counting Misiurewicz points, i.e. points with a pure pre-period m and a period n.

9:10–9:25

The History of the Primality of One

Angela Reddick
University of Tennessee at Martin

It has often been asked if one is prime number, or if there was a time when most mathematicians thought one was prime. Whether or not one is a prime is simply a matter of definition, but definitions are often decided by the use of mathematics. In this paper we will explore the history of the definition of prime as applied to the number one, from the ancient Greeks to the modern times. For the Greeks the numbers ($\alpha\rho\iota\theta\mu o\varsigma$) were multiples of the unit, and for this reason one did not fall into the category of primes (a subdivision of the numbers). This view held with few exceptions until Stevin (c. 1685) argued successfully one was a number, at which point it finally makes sense to ask if one is prime. This is followed by a period of confusion which begins to dissipate with Gauss' *Disquisitiones Arithmeticae*. Thus, for most of history, one was not considered a prime, and that there was no point in time where the majority of mathematicians viewed one as prime. Finally, we discuss who was the last mathematician to consider one a prime.

9:30–9:45

Multiple Choice Versus Open Response Assessment in Calculus

Monica Lee Chalke
Bridgewater State University

The use of multiple choice questions is becoming increasingly common in recent years as an assessment tool in Calculus. The ease of grading of multiple choice questions has lead to their widespread use to assess student understanding on homework assignments via online homework systems as well as on tests. Motivated by the question of whether or not it is appropriate to use multiple choice questions on quizzes and exams in Calculus, we conducted a study to investigate the impact of multiple choice questions versus open response questions on student understanding. The goal of our study is to identify if there is a performance gap between Calculus students who were tested via multiple choice questions on quizzes and exams versus students whose exams consisted only of open response questions. We also investigate the performance of students on particular Calculus topics when assessed using these two methods.

9:50–10:05

Symmetry of the Numerical Range

Shelby Burnett and Ashley Chandler
Cal Poly San Luis Obispo

The numerical range of an $n \times n$ matrix A is a convex subset of the complex plane defined by $W(A) = \{\langle Av, v\rangle : v \in \mathbb{C}^n, \|v\| = 1\}$. The numerical range is said to have n-fold symmetry about the origin if $z \in W(A)$ implies $e^{\frac{2\pi i}{n}} z \in W(A)$. If A is a 2×2 matrix then A is a possibly degenerate elliptic disk with foci at the eigenvalues of A. Naturally, symmetry results for this case have been fully explored. We also know that if the entries of A are real (or A is unitarily equivalent to a real matrix), then $W(A)$ is symmetric about the real axis. In our talk, we will discuss natural generalizations of these results to $n \times n$ matrices where $n \geq 4$. Specifically, we will focus on n-fold symmetry about the origin and symmetry about particular axes.

MAA Session #3

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

8:30–8:45

Variations of Lollipops and Their Pebbling Numbers

Emily Marie Walther
Westminster College

This talk will first focus on understanding the fundamental concepts of pebbling and the pebbling numbers of common graphs such as paths, complete graphs, and cycles will be discussed. The pebbling number of an even cycle lollipop will be determined. We will explore the pebbling number of an odd cycle lollipop and other generalizations of the even cycle.

8:50–9:05

Non-Trivial Pursuit: A Game of Cops and Robbers

Kirstyn Baker, Caitlin Graff, Anthony Graves-McCleary,
Philip Thomas, and Aashish Srinivas
*Alma College, Idaho State University, Vassar College,
Indiana University, and Swarthmore College*

Cops and Robbers is a game played on a reflexive graph by a robber and a team of cops. The cops and the robber take turns moving between adjacent vertices of the graph with the goal of the cops being to eventually occupy the same vertex as the robber, and the robber trying to avoid this result indefinitely. The cop number of a graph is defined as the fewest number of cops needed to capture the robber given intelligent play from both sides. We examine the properties of the cop number for various classes of graphs.

9:10–9:25

Pebbling on Graphs

Mark Schrecengost and Wes Galbraith
Hope College

The pebbling problem arises from a game in graph theory. Pebbles are configured on the vertices of a graph G, and a pebbling move consists of removing 2 pebbles from any vertex and adding 1 to an adjacent vertex. A configuration is said to be *solvable* if, given any starting configuration, at least one pebble can be moved to any vertex through a finite sequence of pebbling moves.

The smallest number of pebbles that guarantees solvability of any configuration on G is called *pebbling number* of G. The *pebbling threshold* of a family of graphs is a function $g(n)$ such that any configuration with $t << g(n)$ is almost always not solvable and with $t >> g(n)$ is almost always solvable, where $t = t(n)$ is the number of pebbles and n is the number of vertices of a graph. We examined the pebbling threshold of diameter two graphs and estimates for the pebbling number of graphs of fixed diameter.

9:30–9:45

Deterministic Walks on Graphs with Choice

Peter Barr
Wake Forest University

In this talk we consider deterministic movement on graphs, integrating local information, memory and choice at nodes. The research is motivated by recent work on deterministic random walks and applications in multiagent systems. Several results regarding passing messages through grids are discussed, as well as some open questions.

9:50–10:05

Compatible Matchings in Bipartite Graphs

Allison Zale
Illinois State University

Consider a graph G whose edges are colored with t colors, where the coloring is not necessarily proper. A subset of vertices S in G is called feasible if for each color c, the vertices in S are saturated by a matching with edges of color c. The problem of devising an efficient algorithm to find the largest feasible subset S is an open question for $t \geq 2$. In our research we developed a greedy algorithm for finding a feasible subset S when G is a bipartite graph and the number of colors is $t = 2$.

10:10–10:25

Pebbling a New Type of Graph

Brandon Mosley
Westminster College

In this talk we will explore various pebblings of a new type of graph. We will conjecture and prove a formula for the pebbling number of the graph, and the generalize to other related graphs.

MAA Session #4

Room: Meeting Room N **8:30A.M. – 10:25A.M.**

8:30–8:45

Equal Circle Packing on a Square Flat Klein Bottle

Matthew Brems and Alexander Wagner,
Franklin College and Vanderbilt University

The study of maximally dense packings of disjoint equal circles is a problem in Discrete Geometry. The optimal densities and arrangements are known for packings of small numbers of equal circles into hard boundary containers, including squares, equilateral triangles and circles. In this presentation, we will explore packings of small numbers of equal circles into a boundaryless container called a Klein bottle. Using numerous figures we will introduce all the basic concepts (including the notion of a Klein bottle, an optimal packing and the graph of a packing), illustrate some maximally dense arrangements, and outline the proofs of their optimality. This research was conducted as part of the 2012 REU program at Grand Valley State University.

8:50–9:05

Perimeter-minimizing Planar Tilings by Pentagons

Zane Karas Martin
Williams College

Hales proved that regular hexagons provide the least-perimeter way to partition the plane into unit areas. What are the best pentagons? Could mixtures of nonconvex and regular pentagons have less perimeter than convex irregular pentagons?

9:10–9:25

Tiling Space with Tetrahedra

Andrew Richard Kelly
Williams College

What is the least-perimeter way to tile space with tetrahedra?

9:30–9:45

Tiling Space with n-Hedra

Steven Waruhiu
University of Chicago

What is the least-perimeter way to tile space with n-hedra for small n?

9:50–10:05

Non-periodic Tessellations and Quasicrystals

Karleen J. Stevens
Augsburg College

This paper explores the relationship between two- and three- dimensional non-periodic tessellations. These ideas are then extended to the chemical world in relation to quasicrystals.

10:10–10:25

Isoperimetry in the Plane with Density e^{r^a}

Whan Ghang
Massachusetts Institute of Technology

We study the isoperimetric problem in the plane with density e^{r^a}. Sometimes as in the Euclidean plane the solution is a circle about the origin, sometimes not.

MAA Session #5

Room: Meeting Room O **8:30A.M. – 10:25A.M.**

8:30–8:45

An Investigation of Boundrary Conditions for the Yee Scheme in Complex Geometry

Phil Ammirato, Kaitlyn Eichinger, Rita Vander Stad,
Alexander Michael Hegedus, and Catherine Ross
*SUNY Stony Brook, University of Kentucky, William Paterson State University,
Alma College, and Rose-Hulman Institute of Technology*

In this paper we will explore how waves acting under Maxwell equations interact with various shapes. We use an application of Yees method to solve Maxwells equations (Kane Yee, 1966, "Numerical solution of initial boundary value problems involving Maxwell's equations in isotropic media", IEEE Transactions on Antennas and Propagation). Complex geometry will be addressed using an Embedded Boundary method or a Cut Cell method over a uniform grid. We plan to numerically investigate the impact of these boundary methods on the divergence free Maxwell equations. We will implement these techniques in Python using various libraries such as NumPy and MatPlotLib. We also may explore the use of GPUs in decreasing computation time.

8:50–9:05

Turing Patterns via Agent-Based Modeling

Joshua Armstrong, Joshua Fagan, Kirstin Ladas, Gavin McGrew, and Rosa Romano
University of Richmond

In a seminal 1952 paper titled "The Chemical Basis of Morphogenesis", Alan Turing proposed that interactions between a slowly-diffusing activator coupled to a rapidly-diffusing inhibitor could produce spatial patterns in the concentrations of those substances. Traditionally, these reaction-diffusion systems have been modeled using partial differential equations (PDE).

$$\frac{\partial a}{\partial t} = f(a,b) + D_a \frac{\partial^2 a}{\partial x^2}$$
$$\frac{\partial b}{\partial t} = g(a,b) + D_b \frac{\partial^2 b}{\partial x^2}$$

Here $f(a,b)$, $g(a,b)$ account for interactions between the chemical species; the extra terms account for the effects of diffusion. These PDE models describe concentrations rather than individual molecules.

In the agent-based models we will use, the molecules will be the agents, and will have their own properties, properties that can determine the nature of their interactions. For example, molecules with the property "speed" may interact through collisions and their speeds will dictate whether the energy of collision is greater than the activation energy necessary for a chemical reaction to occur. Using Mathematica, we are able to explore PDE models by implementing finite differences that are Forward-in-Time-Centered-in-Space. Using NetLogo, an agent-based modeling environment, we are able to account for individual molecules. We will replicate and compare pattern formation in Mathematica with our results in NetLogo.

9:10–9:25

Comparison of the Influence of Sub-Networks on the Global Dynamics of Three-Gene Regulatory Networks in Boolean and Continuous Frameworks

Miranda Henderson
Benedictine University

We discuss the Boolean and continuous dynamics of three-gene regulatory networks. We investigate how the presence of certain sub-networks dictate the dynamics for the entire network. We determine the conditions on these sub-networks that lead to the same or different qualitative behavior of the Boolean and continuous dynamics for the entire network.

9:30–9:45

Pivotal Quantities, Bifurcation Continuation, and Inverse Modeling of Dynamical Systems

Karleigh Cameron and Marissa Saladin
Central Michigan University and Aquinas College

Often when we use a system of equations in mathematical modeling applications, we need to be able to determine unknown parameters. Conditioning has the potential to improve the identifiability of the estimation problem. Conditioning likelihoods are typically much simpler to model than the full joint distribution which may be difficult or impossible to estimate analytically. Bifurcation continuation can inform us about feature statistics of bi-stable systems. We will be using a likelihood based estimation procedure and a Monte Carlo simulation to compare bias accuracy among various estimators. In addition, we will explore how different sources of noise manifest within a dynamical model and how such noise affects uncertainty in the statistical analysis. Systems analyzed have applications to neuroscience and cognition.

9:50–10:05

Inverse Modeling of Dynamical Systems: Multi-Dimensional Extensions of a Stochastic Switching Problem

Erik Bates, Blake Chamberlain, and Rachel Gettinger
Michigan State University, Susquehanna University, and Saint Vincent College

The Buridan's ass problem is characterized by perpetual indecision between two states, which are never attained. When this problem is formulated as a dynamical system, indecision is modeled by a discrete-state Markov process determined by the systems unknown parameters. Interest lies in estimating these parameters from a limited number of observations. In this talk, we compare estimation methods and examine how well each can be generalized to multi-dimensional extensions of this system. We also examine the robustness of these methods when noise is introduced to the system. Conditioning has the potential to improve the identifiability of these inverse problems. In addition, conditioning likelihoods are often simpler than the full joint distribution, which may be difficult or impossible to find analytically. We will quantify various feature statistics such as amplitude, average value, variance, cumulative power, and frequency. We will compare method of moments type estimators to likelihood-based Monte Carlo simulations conditioned on these feature statistics.

10:10–10:25

Some Applications of Bifurcations in Chemistry, Biology and Engineering

Caleb J. Yonker and Michael Esch
Grand Valley State University

The mathematical concept of bifurcations has widespread applications in Engineering and the applied sciences such as Chemistry and Biology. It is especially useful in predicting how dynamical systems which commonly arise in real-life applications evolve with time. In this talk, we perform an in-depth analysis of the mathematical concepts behind some common applications of bifurcations in Chemistry, Biology and Engineering. In particular, we apply analytical techniques such as linearized stability analysis of equilibrium points and geometrical techniques where such analytical techniques fail to understand why the real-life outcomes of such applications appear as they do.

MAA Session #6

Room: Meeting Room P **8:30A.M. – 10:25A.M.**

8:30–8:45

Beal's Conjecture, Lesser-known Brother of Fermat's Last Theorem

Jakob Weisblat
Kent State University

Most people know a certain amount about Fermat's Last Theorem ($a^n + b^n = c^n; n \in \mathbb{Z}^{>2}$) and its history. However, there is another, more general, conjecture, proposed in the 20th century, that still has not been proved or disproved. Beal's Conjecture, also known as the Tijdeman-Zagier conjecture, states that all solutions to the equation $a^x + b^y = c^z$ ($x, y, z \in \mathbb{Z}^{>2}$) have a, b, and c coprime. This talk will discuss a personal search for patterns in the coprime solutions, some general coprime solutions, and finally some possible proof angles and progress of research in the last 20 years.

8:50–9:05

Determining the Primality of a Given Integer is Easy

Tim Shaffer
Youngstown State University

It is well known that determining the prime factorization of a given integer can be quite computationally expensive. In fact, outside of quantum computing, the most efficient factorization algorithm known runs a little faster than in exponential time. What may not be so well-known is that polynomial time algorithms exist that can determine the primality of a given integer. In this presentation the Agrawal, Kayal, and Saxena (AKS) algorithm and the mathematics behind the method are given, along with a comparison with other techniques, such as non-deterministic tests for "probable primes". Consideration for how this algorithm can be implemented and applied to the search for prime numbers will also be discussed.

9:10–9:25

A Constructive Proof of the Cubic Case of Kronecker-Weber

Michael Mudarri
Hood College

The Kronecker-Weber theorem, first proved at the end of the 19^{th} century, states that any abelian extension of the rational numbers $\mathbb{Q}$ is contained in a cyclotomic extension of $\mathbb{Q}$. Let f be a cubic polynomial with rational coefficients whose discriminant is a perfect square in $\mathbb{Q}$. The Kronecker-Weber theorem implies that the roots of f can be expressed as cyclotomic numbers, i.e. as $\mathbb{Q}$-linear combinations of roots of unity. The usual proofs of the theorem are not evidently constructive. I will discuss an algorithm for constructing a representation of the roots of f as cyclotomic numbers using the cubic formula and classical facts from the theory of cyclotomy.

9:30–9:45

Computational Exploration of Pseudo-Arithmetic Super Sets in $\mathbb{Z}[\sqrt{-2}]$

Joshua Jacobson
St. Olaf College

A set $B \subseteq \mathbb{Z}[\sqrt{-2}]$ is defined to be pseudo-arithmetic if for $d(B) = \{x - y | x, y \in B\}$, there exists an element of $d(B)$ that divides all other elements of $d(B)$. A set A is defined as a pseudo-arithmetic super set if for every subset $B \subseteq A$ with card$(B) \geq 2$, B is pseudo-arithmetic. This notion was introduced by Blanchard 2004, and these sets have been classified in the integers, Gaussian integers, and Eisenstein integers. Through examples, we show a variety of pseudo-arithmetic super sets in $\mathbb{Z}[\sqrt{-2}]$. We consider bounded and maximality of these sets as well as standard extensions to these sets. We will also discuss the unit-connected pseudo-arithmetic super sets.

9:50–10:05

Finding Minimum Step Number of Figure-Eight Knot Confined to Slabs in the Simple Cubic Lattice

Michael Jun
UC Berkeley

Knots are commonly found in DNA and proteins and provide clues for topological analysis of their structures. Key parameters to consider in such studies are the minimum number of monomers required to construct a knot and the volume confinement in which the constructions take place. We thus approach the problem by considering the minimum length (minimum step number) needed to form a knot in the simple cubic lattice confined between two parallel planes (or by a slab). The minimum step number of a trefoil in a 1-slab has been determined to be 26 by using the Minimum Step Number (MSN) Algorithm. Though a very systematic approach, the MSN Algorithm becomes very complicated and expensive when extended to larger knots. The focus of this study is creating a computer program to aid with the enumerations. With the computer assistance, we confirm that the minimum step number of a trefoil in the 1-slab is indeed 26. Furthermore, the goal is to generalize this to the figure-eight knot, hoping to put a definite number on the minimum step number of the figure-eight knot.

PME Session #1

Room: Meeting Room O **2:00P.M. – 3:55P.M.**

2:00–2:15

Anagrams, Markov's and Knots

Liliana Alvarez
Austin Peay State University

Our research objective is to observe the interplay of words created from scrambled letters in relation to Markov chains. Thereafter, we will study the words with regards to different types of knots. We applied stochastic modeling to anagrams that formed Markov chains. We used graph theory as an instrument to see the linkage between the world of literature and knot theory.

2:20–2:35

Vertex Polygons

Candice Nielsen
Elmhurst College

We identify necessary conditions for equal-area hexagons to have vertex quadrilaterals with equal area, discover a method for creating a hexagon whose vertex quadrilaterals have equal area without being equal-area, and generalize to construct any polygon with an even number of sides to have certain vertex polygons with equal area.

2:40–2:55

4-move Reducibility of Cables of $(2p + 1, 2)$ Torus Knots

Andrew Tew
University of Nebraska at Omaha

In 1979, Y. Nakanishi conjectured that the 4-move operation is an un-knotting move. This conjecture is assumed to be false, even though no counterexample has been found and every knot with 12 or fewer crossings has been verified as being 4-move reducible to the unknot. It was believed for sometime that the 2-cable of the trefoil knot was a potential counter-example to the 4-move conjecture. However, in his paper "A Note on 4-Equivalence", Nikolaos A. Askitas presented a sequence of 4-move (along with ambient isotopies) that reduced the 2-cable to the unknot. Askitas claims that an inductive proof exists that all 2-cables of $(2p+1, 2)$ torus knots are 4-move reducible to the unknot. This project seeks to explore the inductive argument.

3:00–3:15

The Complement of Fermat Curves in the Plane

Ariel Setniker
Western Oregon University

A plane algebraic curve is a curve defined implicitly by a relation of the form $f(x, y) = 0$, where $f(x, y)$ is a polynomial in x and y. A curve is said to be rational if it can be parametrized by rational functions $x(t), y(t)$. In this talk we will discuss necessary conditions for a rational curve to be defined on the complement of high degree algebraic Fermat curves.

3:20–3:35

Points on a Circle with Integer Distances to Vertices of an Inscribed Equilateral Triangle

Sarah Ritchey

Youngstown State University

Given a circle and inscribed equilateral triangle with integer side lengths, we provide a solution to the Pi Mu Epsilon Journal problem #1245 prepared by S. Rabinowitz, showing that there exists a point on the circle with integer distances to the two closest vertices of the triangle.

3:40–3:55

Proofs Using Complex Numbers

Bradley Slabe

Youngstown State University

In this presentation, we use methods of complex numbers to prove two theorems of geometry, Euler's Triangle Theorem and Ptolemy's Theorem. We finish by using residue theory to evaluate some infinite series.

PME Session #2

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

2:00–2:15

Using Differential Algebra to Solve Differential Equations

Daniel White

Fordham University

Most approaches to solving systems of differential equations rely on numerical techniques from advanced calculus. We are using techniques from differential algebra to solve systems polynomial equations that arise from systems of ordinary systems of differential equations symbolically by using the Dixon Resultant.

2:20–2:35

Bifurcation and Non-convergence in Hansen-Patrick's Root Finding Method

Preston Hardy

St. John's University

Hansen-Patrick's root finding method is a family dependent on a single parameter alpha. It is known there are polynomials for which these methods do not converge to a root, but instead converge to an attracting period n-cycle. We explore what happens to these cycles when the Hansen-Patrick parameter alpha varies.

2:40–2:55

Neither Rain, Nor Sleet, Nor Snow. What About the Internet?

HanQin (Caesar) Cai

St. Norbert College

The internet is having a profound impact on the United States Postal Service. The volume of "snail mail" sent in this country decreased by 42.36% from 2008-2009. In 2010, I participated in a group competition studying this effect and this talk will revisit and update our results.

3:00–3:15

A Scale, Some Coins, A Problem

Sarah Stiemke

St. Norbert College

This is a variation of the classic counterfeit coin problem. Given a collection of n coins of weights 1, 2, or 3 grams and a balance scale, we prove the minimum number of weighings needed to determine the weight of each coin is n.

3:20–3:35

Contracting and Rotating Ellipses

Wilson Cheung
State University of New York at Geneseo

The correlation between the area of a region and the number of lattice points contained within it has been an ongoing area of interest in the field of number theory. The problem arises from Gauss's Circle Theorem, which shows that the number of lattice points within a circle is approximately equal to the area of the circle. Previous results have determined an upper bound for the number of lattice points in the interior region formed by two hyperbolas. In this talk, we will generalize this result to the specific case of two ellipses and conclude that the area of the interior region formed by these ellipses has the same upper bound. We'll describe how the area and the number of lattice points change under contractions and rotations. This is a joint research project with Patrick Rault.

3:40–3:55

Jacobian for n-Dimensional Quasipolar Coordinates - Easy Proofs in All Cases

Tan Nguyen
University of Nevada – Las Vegas

The n-dimensional quasipolar coordinates are defined as a generalization of the polar coordinates (2-d) and the spherical coordinates (3-d). A short elegant proof for the Jacobian of the n-dimensional quasipolar coordinates for the general case is introduced. The special case of $\theta_k = \frac{l_k \pi}{2}$ $(l_k \in \mathbb{Z})$ for some $k = 1, 2, 3, \ldots, n-1$ is covered separately using a method that we call a perturbative (not perturbation) method. The results are then applied for the evaluation of the quasivolume of the n-dimensional quasiball.

MAA Session #7

Room: Meeting Room K **2:00P.M. – 3:55P.M.**

2:00–2:15

Characterization of Melanoma and Moles using Signature Curves, Invariant Histograms and Fractal Dimension

Jack Stangl, Aaron Rodriguez, and Rimi Bhowmik
University of St. Thomas

This presentation focuses on the mathematical detection and analysis of border irregularity in skin lesions, for the purpose of identifying malignant melanoma amongst benign moles. In particular, it utilizes three different methods. The method of Signature Curves is based upon the curvature and the derivative of curvature for a given skin lesion, the method of Fractal Dimension is based upon the box counting method, and the method of Invariant Histograms is based upon cumulative distance histograms. The border irregularity of known malignant melanoma samples are compared to the border of known nevi, or common moles. We propose that melanoma possess distinguishable border differences from nevi, often undetectable to the human eye. We utilize these mathematical methods to detect and quantize this difference for diagnosis.

2:20–2:35

Modeling Spiking in Neurons with a Poisson Process

Peter Wiese
Augustana College

In the nervous system, nerve cells communicate through changes in ion concentrations called action potentials, or spikes. These spikes have been recorded and studied to understand the change in their distribution due to the presentation of a stimulus. By using a Poisson process, it is possible to model the distribution of spikes in time. Based on physiological properties, changes in the model are made to account for both the absolute refractory period and bursting of spikes. We will present several different models implemented on a spread sheet, both of a single neuron and of small systems of neurons.

2:40–2:55

A Comparison of Optimization Techniques in an Artificial Neural Network Modeling Attentive Response to Threatening Stimuli

Benjamin Douglas Ritz
Clarkson University

Several artificial neural network architectures have been constructed to model the human brain's attentive response to threatening and non-threatening stimuli. Multiple experimental trials have been conducted to measure the brains response to stimuli. We examine specifically experiments involving attentive response to visual or somatosensory stimulus. During these experiments, electrophysiological data regarding activity within different portions of the subject's brain is collected. In the experiments, subjects are presented with a cue to direct their attention toward a particular expected stimulus. They then receive a stimulus, which may or may not be the cued stimulus, and record the stimulus they receive. From these experiments, we can refine the artificial neural networks to fit the electrophysiological data we collect.

These artificial neural network architectures are optimized to fit data from the physical experiments. Using optimization tools, model parameters are fit to these data. These parameters can vary from the strength of a particular connection in the architecture to the connections very existence. We examine both which model architecture best fits the electrophysiological data and which optimization tool achieves the best fit for each model. From this, we can determine not only which model is most plausible for describing the brains attentive response to threats, but additionally what optimization tools are best used for doing so.

3:00–3:15

Mathematical Modeling of Chromatography

Ted Samore
Rose-Hulman Institute of Technology

The estrogen receptor protein has important regulatory functions and contributes to breast cancer development. The purified protein exists in equilibrium between monomers and dimers. We performed size-exclusion chromatography and dimer exchange assay experiments for the ligand-binding domain of the protein. We also mathematically modeled the chromatography using nonlinear convection diffusion equations and then compared the results of the experiments with the simulations to estimate the association and dissociation rate constants for the purified protein.

3:20–3:35

CO - Mediated Sickle Cell Polymer Melting

Crystal Bennett
North Carolina Agricultural & Technical State University

Sickle cell anemia is a disorder caused by a mutation in DNA that replaces the nucleic acid Glutamic with Valine. This replacement causes a change in the characteristics of hemoglobin that allows the monomers, the simplest units of chemically binding molecules, to stick together. These chains of monomers, called polymers, distort the shape and properties of the red blood cell. The malformed cells do not efficiently pass through capillaries or transport oxygen to the bodys tissues. In order to make these cells more effective, the polymers must be broken apart. The process of breaking polymers apart is called melting. In the referenced study, the melting was induced by immersing the polymers in a buffer solution containing carbon monoxide. The mathematical model of this process was produced in a separate study. The purpose of this paper is to analyze and reproduce the current mathematical model using various computational and numerical tools.

3:40–3:55

Analysis of Spatio-Temporal Mapping

Lindsay Christie
Clarkson University

Spatio-temporal mapping (STM) is a two-dimensional diagram which allows a user to visualize a series of movements over a spatially moving field. STM can be utilized to analyze several biological applications, including but not limited to, gastrointestinal motility. We use image decomposition of the ST maps to fully understand the frequency of the intestinal contractions that occur within Danio rerio, also known as zebrafish. In addition, we can use STMs in order to create software that predicts valuable information such as the velocity and duration of each individual contraction. This can help accelerate future research pertaining to the origin of common digestive diseases and potential cures.

MAA Session #8

Room: Meeting Room L **2:00P.M. – 3:55P.M.**

2:00–2:15

Graphs with Equal Domination Number and Identification Number

Julie Elizabeth Lang and Lindzey Brooke Thacker
Morehead State University

The domination number of a graph is the minimum cardinality of a subset of vertices S such that all vertices are either in S or adjacent to a vertex in S. The identification number is the minimum cardinality such that the intersection of S with the closed neighborhood of each vertex is distinct. This presentation will discuss instances in which the domination number and the identification number are the same as well as a method of constructing such graphs.

2:20–2:35

Sum and Product Connectivity Indices of Single Cyclohexane Compounds

Katrina Bandeli
Montclair State University

This research deals with Product (Randc) and Sum Connectivity Indices of graphs of Single Cyclohexane Compounds called SCC graphs. These graphs of special interest are built from a single hexagon base along with long branches or trees. We are particularly interested in an SCC graph where the connection between the hexagon and the tree part is by one edge. Formulas are developed for the indices of certain types of such graphs. We compare such SCC graphs with those with attachments of a star or a path. We show that among these types of graphs the Randc index of the hexagon attached to a path is almost the largest, and the Randc index of the hexagon attached to a star is almost the smallest. It is known that the product index is one of the most successful molecular descriptors for structural-property and structural-activity relationship studies.

2:40–2:55

Minimum Exponential Dominating Sets of Cycles Connecting at One or Two Vertices

Amanda Bright
Westminster College

The purpose of this research is to explore the behavior of minimum exponential dominating sets of two separate and equal cycles when they are connected at one or two vertices. It is well known that the size of a minimum exponential dominating set for a cycle of size n is $\lceil n/4 \rceil$ for $n \neq 4$ and 2 for $n = 4$. When two cycles of size n are connected at one vertex, we are going to prove that the size of the resulting minimum exponential dominating set is $2\lceil n/4 \rceil - 1$ for $n \neq 4$ and 2 for $n = 4$. We are also going to discuss the conjecture that the size of the minimum exponential dominating set of two cycles of size n which are connected at two vertices distance d apart is given by $2\lceil n/4 \rceil - 1$ when $d < n$ mod 4 and $2\lceil n/4 \rceil - 2$ when $d \geq n$ mod 4. These results can provide valuable information in the research of exponential domination and in graph theory.

3:00–3:15

On d-modular Labelings of the Union of Two Cycles

Joseph Buchanan
Illinois State University

For positive integers r and s, let $K_{r\times s}$ denote the complete multipartite graph with r parts of size s each. Let G be a graph with n edges, d be a positive integer such that $d|2n$ and set $c = 2n/d + 1$. A *d-modular ρ-labeling* of G is a one-to-one function $f\colon\ V(G) \to [0, cd)$ such that $\{\min(|f(u) - f(v)|, cd - |f(u) - f(v)|)\colon\ \{u, v\} \in E(G)\} = \{1, 2, \dots, \lfloor \frac{cd}{2} \rfloor\} \setminus c\mathbb{Z}$.

It is known that if a z-partite graph G admits a d-modular ρ-labeling, then there exists a cyclic G-decomposition of $K_{c\times td}$ for every positive integer t such that $\gcd(t, (z - 1)!) = 1$. We investigate d-modular labelings of the union of two vertex-disjoint cycles.

3:20–3:35

On 2-fold Graceful Labelings

Ellen Sparks
Illinois State University

Let $\mathbb{Z}$ denote the set of integers and $\mathbb{N}$ denote the set of nonnegative integers. For integers a and b with $a \le b$, let $[a, b] = \{x \in \mathbb{Z} : a \le x \le b\}$. For a positive integer k, let ${}^2K_k$ denote the 2-fold complete mutigraph of order k. Similarly, let ${}^2[a, b]$ denote the multiset that contains every element of $[a, b]$ exactly two times. Let G be a multigraph of size n, order at most $n + 1$, and edge multiplicity at most 2. A *labeling* of G is a one-to-one function $f\colon V(G) \to \mathbb{N}$. If f is a labeling of G and $e = \{u, v\} \in E(G)$, let $\bar{f}(e) = |f(u) - f(v)|$. A *2-fold graceful labeling* of G is a one-to-one function $f\colon V(G) \to [0, n]$ such that $\{\bar{f}(e)\colon e \in E(G)\}$ is either the multiset ${}^2[1, \frac{n}{2}]$ if n is even or the multiset ${}^2[1, \frac{n-1}{2}] \cup \{\frac{n+1}{2}\}$ if n is odd.

A graph G is said to be *2-fold graceful* if it admits a 2-fold graceful labeling. It can be shown that if G with n edges is 2-fold graceful, then there exists a cyclic G-decomposition of ${}^2K_{n+1}$. El-Zanati has conjectured that every tree is 2-fold graceful. We investigate 2-fold graceful labelings of various classes of graphs including several classes of trees.

3:40–3:55

Direct Sums for Graph Automorphisms

Michael Carlyle
Augustana College

A graph automorphism is a mapping from and to itself that preserves vertex adjacency. After a brief recap of fundamental ideas such as groups and graphs, we will present examples of graphs whose automorphism groups are "easy" to see, and then we will show graphs whose automorphism groups are direct sums. We will also show examples where the techniques of direct sums are not quite enough.

MAA Session #9

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

2:00–2:15

Harmonic Functions and Walk on Spheres

Harini Chandramouli, Nora Stack, and Brandon Reeves

University of Pittsburgh, St. Mary's College of Maryland, and Gonzaga University

In this research we are looking at a classical Kakutani's result on the connection between the Brownian motion, a form of random movement, and harmonic functions, which are solutions to the Laplace equation. Kakutani's theorem is basically a generalization of the mean value property of harmonic functions. We will use this result to solve the Laplace equation in various regions with certain boundary conditions.

Walk on Spheres (WoS) is used to simulate the Brownian motion of a particle suspended in liquid. The average distance travelled by the particle (Einstein's model), as well as the average time needed for the particle to hit the boundary of certain regions will be discussed. The distribution of the point of first encounter with the boundary of the region is of interest to us. We will discuss the rate of convergence of the Brownian motion to the boundary as well as the overall computational effort needed to estimate values of the harmonic function using the Monte Carlo algorithm.

2:20–2:35

Existence of Optimal Parameters for the Black-Scholes Option Pricing Model

Justin Ziegler

Minot State University

Finance is one of the most rapidly changing and fastest growing areas in the corporate business world. Because of this rapid change, modern financial instruments have become extremely complex. New mathematical models are essential to implement and price these new financial instruments. It is a fact that the world of corporate finance, once managed by business students, is now controlled by mathematicians and computer scientists. In this particular interdisciplinary approach, we focus on a ground-breaking result in finance via mathematics, so-called the Black-Scholes model, a widely used tool for valuing options. In this work, we show existence, uniqueness, and continuity of a weak solution with respect to parameters. In addition, existence of optimal parameters are derived.

2:40–2:55

Censored Distributions in Stochastic Simulation of Financial Market Data

Valentina M. Semenova
Dartmouth College

Certain financial market data, such as interest rate and volatility, are non-negative. At the same time, they are often modeled by stochastic processes without lower bound, such as OrnsteinUhlenbeck process. In order to make distribution more realistic, it is necessary to bound it at 0. There are 2 possibilities for bounding: censored distribution and truncated distribution. It is examined how use of truncated distribution modifies statistical moments and correlations. It will be shown that use of censored distribution within the stochastic modeling framework of interest rates and volatilities produce more realistic results than unbounded or truncated distribution. Financial data illustrations include short interest rates and volatilities of foreign exchange rates.

3:00–3:15

Using Wavelet Transformations to Analyze Carbon Uptake

Tyler J. Heaps
Augsburg College

The objective of this study was to apply wavelet transformations to analyze long-term records of carbon uptake at different measurement sites throughout the United States. Wavelet transformations, such as the Haar wavelet transform (HWT), were used to compress the information and reduce the biased and non-useful data. The data were collected from Ameriflux, a network of tower sites that provide quantitative information throughout the United States, and analyzed using MatLab.

Wavelets are useful in modeling a time series on different time scales. The wavelet approach was helpful in analyzing the carbon uptake at a given site, which may have half-hourly data collected over many years. A key measurement analyzed was net ecosystem exchange (NEE), which measures the rate that carbon enters and leaves the ecosystem. The wavelet decomposed NEE was compared to wavelet decompositions of other environmental measurements such as incoming solar radiation and air temperature. My results indicate a moderate linear correlation between the incoming solar radiation and carbon uptake. The smaller differences of solar radiation tended to cause an efflux of carbon into the atmosphere over a 4-6 year period. In shorter time scales, there was no linear correlation between the air temperature and NEE, but over a larger time scale, the higher temperatures allowed for uptake of carbon by the biosphere. Future research would examine the robustness of our findings across a latitudinal gradient and sites with similar vegetation.

3:20–3:35

Positive Solutions to Singular Third Order Boundary Value Problems on Purely Discrete Time Scales

Ashley Martin and Courtney DeHoet
University of Tennessee at Martin

We study singular discrete third order boundary value problems with mixed boundary conditions over a finite discrete interval. We prove the existence of a positive solution by means of the lower and upper solutions method and the Brouwer fixed point theorem in conjunction with perturbation methods to approximate regular problems.

MAA Session #10

Room: Meeting Room N **2:00P.M. – 3:55P.M.**

2:00–2:15

Studying Robotic Mobility Using Inverse Kinematics with Two Different Techniques

Melody Mone't Wilson, Denetra Lynette Porties,
Kristen Danielle Edwards, and Chinae Edmonds
Central State University

The study of robot mobility is important in determining the full capacity in which a robot can operate in any given space. Inverse kinematics in robotics uses an end-effector (robot hand) to calculate the joint angles needed to obtain the position of the end-effector. This study uses inverse kinematics to determine the joint angle mobility of a four degrees-of-freedom robot manipulator using two techniques: Groebner Basis Theory and the Denavit-Hartenberg Matrix. The presenters will use these techniques to analyze the geometry of the robot and solve for the unknown joint angles of the waist, elbow, and shoulder. Since robotic movement is similar to human movement, the presenters will discuss how these results can contribute to studies in human behavior.

2:20–2:35

Towards a Tropical Proof of the Gieseker-Petri Theorem - Part 1

Dat Pham Nguyen
SUNY Stony Brook

Tropical geometry allows for many of the properties of algebraic curves to be studied from a new perspective. Specifically, tropical geometry reduces divisors on a Riemann surface to divisors on a metric graph, which can be easier to work with. This technique has recently been used by Cools, Draisma, Payne, and Robeva to prove the Brill-Noether Theorem (originally proven by Griffiths and Harris) combinatorially. Our project uses the same technique as Cools et al. to provide a combinatorial proof of the rank one case of the Gieseker-Petri Theorem, which was originally proven by Gieseker in 1982.

This part of our talk details the background and motivation of our project.

2:40–2:55

Towards a Tropical Proof of the Gieseker-Petri Theorem - Part 2

Shalin Parekh
SUNY Stony Brook

Tropical geometry allows for many of the properties of algebraic curves to be studied from a new perspective. Specifically, tropical geometry reduces divisors on a Riemann surface to divisors on a metric graph, which can be easier to work with. This technique has recently been used by Cools, Draisma, Payne, and Robeva to provide a combinatorial proof of the Brill-Noether Theorem (originally proven by Griffiths and Harris). Our project uses the same technique as Cools et al. to provide a combinatorial proof of the rank one case of the Gieseker-Petri Theorem, which was originally proven by Gieseker in 1982.

In this part, we introduce the Gieseker-Petri theorem and our approach to a tropical proof of the rank one case.

3:00–3:15

Towards a Tropical Proof of the Gieseker-Petri Theorem - Part 3

Vyassa Baratham
SUNY Stony Brook

Tropical geometry allows for many of the properties of algebraic curves to be studied from a new perspective. Specifically, tropical geometry reduces divisors on a Riemann surface to divisors on a metric graph, which can be easier to work with. This technique has recently been used by Cools, Draisma, Payne, and Robeva to prove the Brill-Noether Theorem (originally proven by Griffiths and Harris) combinatorially. Our project uses the same technique as Cools et al. to provide a combinatorial proof of the rank one case of the Gieseker-Petri Theorem, which was originally proven by Gieseker in 1982.

In this part, we explain the graph used in our proof, and some of its properties.

3:20–3:35

Towards a Tropical Proof of the Gieseker-Petri Theorem - Part 4

Cristina Mata
SUNY Stony Brook

Tropical geometry allows for many of the properties of algebraic curves to be studied from a new perspective. Specifically, tropical geometry reduces divisors on a Riemann surface to divisors on a metric graph, which can be easier to work with. This technique has recently been used by Cools, Draisma, Payne, and Robeva to prove the Brill-Noether Theorem (originally proven by Griffiths and Harris) combinatorially. Our project uses the same technique as Cools et al. to provide a combinatorial proof of the rank one case of the Gieseker-Petri Theorem, which was originally proven by Gieseker in 1982.

In this part, we present our proof.

3:40–3:55

Conics in Taxicab Geometry and Extended Taxicab Geometry

Hope Snyder
Washington & Jefferson College

We analyze and classify conics in Taxicab Geometry. From the analysis, we can visualize and graph these conics before consulting computer software. We will also investigate the conics under Extended Taxicab Geometry, a model described by David Caballero used to simulate the spread of forest fires in Europe. The extended taxicab distance takes into consideration the diagonal distance to cells placed in opposite corners. This causes the shapes of the conics to become stranger than under Taxicab Geometry.

MAA Session #11

Room: Meeting Room K **4:00P.M. – 6:15P.M.**

4:00–4:15

Using Stochastic Differential Equations to Model an Antibiotic-Resistant Infection

Alexandra Signoriello, Pamela Kirkpatrick, and Nicole Fiorentino
Ursinus College, Messiah College, and Muhlenberg College

This project emphasizes the use and comparison of stochastic modeling approaches to derive and analyze models for Vancomycin-resistant enterococci (VRE) infections in an intensive care unit. VRE infections have been linked to increased mortality and costs. Stochastic models are derived from a deterministic model that incorporates the difference between colonization and infection, the role of special preventive care treatment cycles, fitness cost, and antibiotic use. The ultimate goal is to determine the most efficient and economically favorable strategies to control VRE and prevent outbreaks.

4:20–4:35

Hextile Planar Isotopy and Reidemeister Moves

Andreana N. Holowatyj
Benedictine University

A hexagonal knot mosaic is a knot diagram that lies in a regular hexagonal grid in a particular way. We consider planar isotopies and Reidemeister moves that result from exchanging tiles in the grid. We call these moves hextile planar isotopies and hextile Reidemeister moves, respectively. We enumerate basic hextile planar isotopy moves in n-hextile regions and explore methods to catalog the infinitely many basic hextile isotopy moves. Furthermore, any hextile Reidemeister move is hextile planar isotopic to one of a set of finite moves.

There may be abstracts for this session received too late to appear in print.
Please refer to the MAA Student web page at:
`http://www.maa.org/mathfest/students.cfm`
for presenters' names, talk titles, and abstracts.

MAA Session #12

Room: Meeting Room L **4:00P.M. – 6:15P.M.**

4:00–4:15

Exploring How Network Homophily Relates to Subgroup Calculation

Jeffrey Nielsen
United States Military Academy

Homophily in a network is a measurement of the extent to which individual nodes create links with nodes of similar attributes more often than those unlike themselves. A subgroup is a collection of nodes within a network that are more closely linked to each other than the rest of the network. After defining these terms and discussing how they are calculated, this talk explores whether homophily in a network might drive its subgroup formation by correlating homophily at the node level with the homophily of any subgroup containing that node. This correlation could inspire a search for an analytical relationship between homophily and subgroup creation, and therefore open a new set of research topics within network science. This project analyzes a data set consisting of 140 cadets of the United States Military Academy and centers on homophily by gender while using both a top-down and bottom-up algorithm for subgroup calculation.

4:20–4:35

Linkless Embeddings of Permutation Graphs

Joshua Wilson
SUNY Potsdam/St. Olaf College

Let G be a graph on n vertices, and let α be a permutation of the vertices of G. Drawing inspiration from the Petersen graph, Gary Chartrand and Frank Harary in their 1967 paper "Planar Permutation Graphs" define the α-permutation graph of G, $P_\alpha(G)$, to be the graph formed by taking two copies of G and joining a vertex v of the first copy of G to the vertex $\alpha(v)$ of the second copy of G. Under the hypothesis that G is 2-connected, they find necessary and sufficient conditions for $P_\alpha(G)$ to be planar. In our work we seek to extend their results to linkless embeddings. A linkless embedding of a graph is an embedding so that every pair of disjoint cycles form a split link. We work on finding necessary and sufficient conditions for $P_\alpha(G)$ to have a linkless embedding.

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MAA Session #13

Room: Meeting Room M **4:00P.M. – 6:15P.M.**

4:00–4:15

Is Elliptic Curve Cryptography Secure?

Mehak Sandhu and Gonzalo Landeros
Benedictine University

Several public key cryptographic methods like the Diffie-Hellman key exchange and the ElGamal cryptosystem are based on the Discrete Logarithm problem. If we try to solve the DLP using the trial and error method, it takes exponential time. There are faster ways to solve the DLP in F_p^* with multiplication, however the best known algorithm is subexponential. The DLP problem for elliptic curves (ECDLP) is believed to be even more difficult; using the currently known algorithms it takes exponential time to solve this problem. Therefore companies like BlackBerry use Elliptic Curve Cryptography in some of their operations. But the cat and mouse game of crypto goes on. Recently in April 2012 there was a paper that challenges the statement that there is no subexponential algorithm to solve the ECDLP. In this expository work we attempt to understand the underlying mathematics behind some of these techniques in the rapidly evolving field of cryptology.

4:20–4:35

Star Studded Mathematics

Mark Kleehammer
SUNY Fredonia

In this talk we will explore the interior angle sum of stars. We will look at complete stars and apply the results to prove Barbier's Theorem for Reuleaux Polygons.

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MAA Session #14

Room: Meeting Room N **4:00P.M. – 6:15P.M.**

4:00–4:15

Riemannian Geometry and a Little Ricci Flow

Taylor Klotz
University of Colorado at Colorado Springs

This talk will focus on presenting some of the most fundamental parts of Riemannian Geometry. Particularly those concepts needed to understand a rather useful idea known as Ricci flow. Riemannian manifolds, connections, Christoffel symbols, and the curvature tensors will be presented (rather quickly) so that we may begin to explore the elementary ideas of the Ricci flow equation. If time permits, a few examples of solutions to the Ricci flow equation will be presented, and their geometric implications will be discussed. If possible there will also be a brief aside on the use of the Ricci flow equation in Perelman's proof of the Poincaré conjecture.

4:20–4:35

On the Equilateral Dimension of Complete Riemannian Manifolds with Bounded Curvature

Jeremy Mann
Johns Hopkins University

The equilateral dimension of a given metric space is the maximum number of points that are all the same distance from each other. For spaces of constant curvature, such as the R^n and S^n, the equilateral dimension is purely a function of the space's dimension as a manifold, $n + 1$ and $n + 2$, respectively. My results use various Comparison Theorems that give an upper bound on the equilateral dimension under various bounds on the Ricci or sectional curvature.

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for presenters' names, talk titles, and abstracts.

PME Session #3

Room: Meeting Room O **4:00P.M. – 6:15P.M.**

4:00–4:15

Low Dimension Lie Algebra Dimension Reduction by Modding by the Center

Nick Benthem

Grand Valley State University

We investigate reducing the order of real low dimensional Lie algebras by modding by the center. We find the isomorphism between the reduced algebra and one of the non-decomposable Lie algebras and explain why in certain cases the reduced algebra decomposes.

4:20–4:35

Markov Chains in Literature: Re-Exploring Markovs Original Applications Using Modern Technology

Anne French

Austin Peay State University

Markov chains have numerous applications throughout mathematics and science, which is something the creator of the chains never thought was possible. Andrey A. Markov thought that his chains would only be applicable in the exploration of literature. His love of poetry led him to use Markov chains to study the alteration of vowels and consonants in Russian literature as a hobby. This presentation demonstrates how the analysis of literature using Markov chains and computer programming can be used to reveal the origination of the nonsense texts of the mathematician Charles Dodson, who is also known as Lewis Carroll.

4:40–4:55

Investigating the Mapping Properties of a Certain Class of Harmonic Functions on the Unit Disc

Cory Medin

Austin Peay State University

A good departure point for investigating harmonic polynomials is to study certain classes of harmonic functions. In particular, we compare the mapping properties of a certain family of harmonic functions with the mapping properties a certain family of Schlicht functions on the unit disc.

5:00–5:15

Benford Melodies: A Senior Thesis on Stochastic Composition

Nathaniel Card

Carthage College

Benfords Law can be applied to many things: addresses, stock prices, and river lengths; however, in this presentation we will explore using Benfords Law to both analyze and create melodies. The principal question being thus: do most melodies follow Benfords Law by the very nature of musical composition and counterpoint, or would composing melodies using Benfords Law create truly original sounding stochastic music.

5:20–5:35

An Analysis of Blackjack Switch

Heather Cook
Roanoke College

Blackjack Switch is an alternative to Blackjack. Each player is dealt two hands and after the second card for each is dealt, the player may switch those two cards. We will discuss changes to Blackjack basic strategy along with other results about the game of Blackjack Switch.

5:40–5:55

A Pictoral Introduction to Knot Theory

Timothy Yeatman
University of South Florida

Mathematicians have trouble distinguishing knots from each other. Knot invariants allow us to determine whether two knots are different. This talk will pictorially introduce the concept of a mathematical knot, and describe some of the methods used.

PME Session #4

Room: Meeting Room P **4:00P.M. – 6:15P.M.**

4:00–4:15

Niven Numbers and Cryptography

Sarah Wesley
Elmhurst College

A Niven number, also called a Harshad number, is a positive integer in any given base that is divisible by the sum of its digits in that given base. When looking at a Niven number m, we can find the sum of its digits and divide the number by the sum of its digits to produce either another Niven number or a non-Niven number. This process can be repeated to produce a chain of equivalent integers until the chain terminates at a non-Niven number or stabilizes at a Niven number. This process has connections to the field of cryptography by establishing patterns of certain Niven numbers and the equivalency chains they produce.

4:20–4:35

Universal Niven Number Representations

Marissa Clougher
Elmhurst College

A positive integer is a Niven or Harshad number when it is divisible by the sum of its digits. A representation of a number is universally Niven if the representation is a Niven number in all standard bases. A procedure for generating universally Niven numbers is given using modular arithmetic.

4:40–4:55

The Derivative, the Integral, and Insect Development: Using a Biological Example to Teach Fundamental Calculus Concepts

Kristen Bosch
Hope College

In Calculus courses, students are often first presented with geometric and physical examples to motivate the concepts of the derivative and the definite integral. I will discuss a real-world biological application-modeling insect development time-that can be introduced early on in Calculus courses to provide additional context for these fundamental ideas.

5:00–5:15

When Prisoners Enter Battle

Sarah Heilig
New York University

I will show the results I found researching the connections between the twelve symmetric 2×2 games. The twelve games can be shown on a 2D $x - y$ axis and can be separated into six different sectors. In each section, the games involved can be manipulated to one common game. I will demonstrate how I was able to find one universal game in each sector, proving that these are more closely related than mathematicians previously believed.

5:20–5:35

A Map Through 'The Elements'

Tyler Brown
Penn State Harrisburg

This project has two major goals: Read the 13 books of Euclid and map out the dependence of each of Euclid's theorems on the Axioms and previously proven theorems. Having collected a complete mapping of the dependencies to create software which can read the data we collect and render it graphically; specifically as a directed graph which shows visually how each theorem depends on those theorems which came before it. Our intention is to create software which is independent of The Elements itself so that it could also be used to map and display the dependency structure of other fields of mathematics, or any other sets of ideas which have a structure of dependence between them. This work was the joint research of Tyler Brown, Siddharth Dahiya, and Joseph Roberge.

5:40–5:55

The Abstract and the Absurd: Lewis Carroll's Reaction to Contemporary Mathematics

Justin Brockmann
University of Wisconsin - Whitewater

Lewis Carroll (Charles Dodgson) was a staunch defender of traditionalism in mathematics. Some of the characters and dialogue he used in his Alice books can be seen as a reaction to the alterations of the mathematical landscape.

6:00–6:15

Symmetry Means Beauty . . . Even In Nature

Emarus Shay
Austin Peay State University

Geometry leads to interesting concepts and beautiful things in life. Considering distance-preserving transformations of the plane, and the set of all symmetries of planar objects, we show both form groups under composition of transformations. Specifically, the symmetry group of a regular n-gon is the Diheadral group, D_n, of order $2n$.

MAA Session #15

Room: Meeting Room K **8:30A.M. – 11:45A.M.**

8:30–8:45

Using Mathematical Modeling and Statistical Analysis to Relate Development Time and Temperature in Bean Beetles

Amanda Schuiling
Hope College

The success of a species within their environment is largely dependent upon its developmental timing. In insects, temperature plays a key role in determining rates of growth and development for various life stages including the embryonic stage. Thus time-lapse photography was used to measure the timing of this stage for bean beetles at various temperatures in the laboratory. Mathematical models were developed to fit these data, and statistical analyses were performed to provide a deeper understanding of the relationships between developmental timing and temperature in insect populations.

8:50–9:05

Two-Prey, One-Predator Model with Impulsive Effects for Integrated Pest Management

Spencer Havis
Benedictine University

We investigate a one-predator, two-prey model for integrated pest solutions. The model features stage structure for all species and birth pulses for the prey species. The birth Pulses, spraying of pesticides, and predator augmentation occur periodically. We establish conditions for which the model exhibits a total pest eradication solution, solutions which one prey is eradicated, and permanent solutions in which all species are maintained.

9:10–9:25

Pattern Formations by Social Interactions During Foraging

Weici Hu
Smith College

Different foraging behaviors and social interactions within a group of animals can form interesting spatio-temporal patterns of foragers and food distribution. Using a system of partial differential equations, we model the movement of foragers which includes random walk and attraction towards prey, as well as the prey movements. We started with a simple forager-prey system and showed it always settles into a spatially uniform steady state. We then investigated the effect of social interactions, in particular we consider two groups of foragers with different behaviors: those who look for prey independently ("foragers") and those who exploit others ("exploiters). We found that the forager- exploiter-prey (FEP) system exhibit spatiotemporal oscillations. We then further studied other possible social interactions between foragers and exploiters, such as the aggressiveness exhibited by the exploiters towards the foragers, and the switching behavior between the foragers and exploiters. While the aggressive behavior of the exploiters tends to stabilize the system, the switching behavior alters the frequency and pattern of oscillation.

9:30–9:45

Mathematical Models of Ant Territorial Boundaries Relating to Aggression

Evan Tomkiewicz and Jessica Burl

Clarkson University

Aggression has always been one of the key determinates in territorial boundaries, not only in humans but also in simpler animals such as ants. Formica subsericea, or shiny black ants, make large mounds in abundance in St. Lawrence County in New York State. A collection of data was taken to get spatial arrangements of individual ant colonies in a field. ArcGIS was used to determine the distances between each colony and create a visible map of all of the data points. Different statistical error methods were applied to check the accuracy of our mathematical model that used tessellations to estimate possible boundary outlines of every colony. The accuracy was further tested by various experiments completed in the field. After that, individual ants were taken from different colonies to analyze aggression levels depending on the distances between their individual colonies. We predicted that closely neighboring colonies would display less aggression compared to farther distanced colonies.

9:50–10:05

Analysis of Diatoms and Arcellacean Death Assemblages

Cory Ali and Illian Rojas

University of Houston - Downtown

In this project, diatom and arcellacean death assemblages were studied to determine if consistent trends exist in the succession of a mitigation wetland ecosystem in Greens Bayou Wetland Mitigation Bank compared to a stable wetland ecosystem in the Anahuac National Wildlife Refuge. The statistical package R (a language and environment for statistical computing and graphics) was used to calculate the various statistical indices used to determine alpha and beta diversity between GBWMB and ANWR. R was used to analyze the raw data and alternatively, the rare species in the diatom and arcellacean assemblage were removed using the theory of listwise deletion and then analyzed by R. The comparison of traditional missing data analyses such as listwise deletion, partial listwise deletion, imputation, and partial imputation via SAS to the inclusion and exclusion of rare genera results used by R were compared to analyze the impact of the rare genera of the diatom and arcellacean death assemblage. This missing data analysis shows that the inclusion of rare genera is important to the succession signal in the mitigation wetland.

10:10–10:25

A Mathematical Model of Prairie Restoration

Michael Frank, Courtney Sherwood, and Lauren Tirado

Simpson College

We present a differential equations model of prairie restoration. Here, species richness is considered as an indicator of prairie restoration, with the variables for the equation being species richness and time. We will incorporate field work from a prairie in Nebraska as an example of our model.

MAA Session #16

Room: Meeting Room L **8:30A.M. – 11:45A.M.**

8:30–8:45

Combinatorial and Computer Proofs of Certain Identities

Michael Weselcouch and Sean Meehan
Assumption College and University of Notre Dame

In this talk we will present combinatorial and computer assisted proofs of certain interesting identities. This research was conducted as part of the 2012 REU program at Grand Valley State University.

8:50–9:05

Analysis of Sudoku Variations Using Combinatorial Techniques

Ellen Borgeld and Elizabeth Meena
Grand Valley State University and Trinity Christian College

Many people enjoy solving Sudoku puzzles, but there are other challenging and intriguing questions about Sudoku that can be studied using combinatorics, such as counting the number of possible Sudoku boards and determining when a puzzle is solvable. Some variations on the standard 9×9 puzzle have different rules, for example, using arrows or other symbols between individual cells rather than numerical clues. We present the results of our research of Sudoku variations, using combinatorial counting techniques including permutations and equivalence relations. This research was conducted as part of the 2012 REU program at Grand Valley State University.

9:10–9:25

Conway's Subprime Fibonacci Sequences

Julian Salazar
Henry Wise Wood High School

It's the age-old recurrence with a twist: add the two preceding terms, and *if the sum is composite, divide by its smallest prime divisor* to get the current term (e.g., 0, 1, 1, 2, 3, 5, 4, 3, 7, ...). This presentation is both an exposition on the properties of this interesting variant (namely, the existence of cycles reminiscent of the $3x + 1$ problem), and a retrospective on how a tri-generational trio approached and collaborated on it.

9:30–9:45

Famous Sequences and Euclidean Algorithm Step Sizes

Gregory James Clark
Westminster College

We will prove that the maximum number of steps for the Euclidean Algorithm is achieved using Fibonacci numbers and Lucas numbers of odd index. In particular, we will use a formula that provides an upper bound on the number of steps needed when using the Euclidean Algorithm on two natural numbers, a and b. Furthermore, we will show that the upper bound is achieved for certain values of b.

9:50–10:05

Irreducible Pairs

Jordan Torf
Illinois State University

Given a positive integer k and two multisets, A and B, we say that A and B form a k-irreducible pair if:

1. the elements in A and B are integers in$\{1, 2, \ldots, k\}$,
2. the sum of all the integers in A is equal to the sum of all the integers in B, and
3. there is no proper subset of integers in A such that the sum of the integers in this subset is equal to the sum of the integers in some subset of B.

In our research, we study the problem of k-irreducible pairs, and, more precisely, the maximum length, $l(k)$, of a k-irreducible pair. Thus, $l(k)$ is that maximum size of the sum of the sets A and B, that satisfy the conditions for k-irreducibility. It can be shown that $l(k)$ is at least $2k - 1$. It is also conjectured that $l(k) = 2k - 1$.

10:10–10:25

A Classification of Quadratic Rook Polynomials

Alicia Velek and Samantha Tabackin
York College of Pennsylvania

Rook theory is the study of permutations described using terminology from the game of chess. In rook theory, a generalized board B is any subset of the squares of an $n \times n$ square chessboard for some positive integer n. The rook polynomial for B is a polynomial that counts how many ways one can place different numbers of non-attacking rooks on B. In our research, we classified all quadratic polynomials that are the rook polynomial for some generalized board B.

10:30–10:45

An Analysis of Beggar-My-Neighbor

Andrew Ardueser, Rachel Rice, and Kelly Woodard
Simpson College

In this talk we will present the work completed in the summer of 2012 during the Dr. Albert H. and Greta A. Bryan Summer Research Program at Simpson College. We are furthering the analysis of the card game Beggar-My-Neighbor specifically with the intent of discovering a deal that leads to an infinite game in a 52-card deck. We are using combinatorics and programs written in Mathematica to examine and refine the large number of possible deals based on structures that lead to cyclic behavior.

MAA Session #17

Room: Meeting Room M **8:30A.M. – 11:45A.M.**

8:30–8:45

Generalized Homological Sequences on Simplicial Complexes

Brian Green, Alex Onderdonk, Kim Rich, and Mike Agiorgousis

Ursinus College, Immaculata University, Bucknell University, and Ursinus College

We define a notion of homological equivalence of discrete Morse functions on simplicial complexes, generalizing a previous notion of equivalence of discrete Morse functions on graphs based on the homology groups of the complex. We show that these sequences are well behaved, and construct discrete Morse functions which yield prescribed integer sequences.

8:50–9:05

An Alternative Definition for the Conley Relation

Junnan He

Australian National University

In the theory of dynamics of closed relations on compact Hausdorff spaces, the definition for the Conley relation f^{Ω} of an iterated closed relation f is nontrivial. This paper establishes a new equivalent definition for f^{Ω}, and discusses its interpretation.

9:10–9:25

Cost-Conscious Voters in Referendum Elections

Lindsey Brown and Hoang Ha

Baker University and Bryn Mawr College

In referendum elections, voters are often required to register simultaneous “yes”/“no” votes on multiple proposals. The separability problem occurs when a voters preferred outcome on a proposal or set of proposals depends on the possible outcomes of other proposals in the election. Previous research has identified cost-consciousness—that is, a desire to limit total public expenditures—as a potential cause of nonseparability in referendum elections. In this talk, we will present new models of cost-consciousness and explore both their theoretical and practical implications. This research was conducted as part of the 2012 REU program at Grand Valley State University.

9:30–9:45

Tight Lower Bounds for Unequal Division

Andrew Lohr

University of Maryland

Alice and Bob want to cut a cake; however, in contrast to the usual problems of fair division, they want to cut it unfairly. More precisely, they want to cut it in ratio $(a : b)$. (We can assume $\gcd(a, b) = 1$.) Let f(a,b) be the number of cuts this will take (assuming both act in their own self interest). It is known that $f(a, b) \leq \lceil \lg(a+b) \rceil$. We show that (1) for all a,b, $f(a, b) \geq \lg(\lg(a+b))$ and (2) for an infinite number of (a,b), $f(a, b) \leq 1 + \lg(\lg(a + b)$.

9:50–10:05

Discrete Markov Chains and Candy Land

James D. Munyon
Youngstown State University

Discrete Markov chains were used to statistically analyze the pastime board game “Candy Land”. By viewing the game in such a mathematical way, much information relating to possible outcomes in a game can be determined. Such information includes: the probability of being on a space after a certain number of card draws, the average number of card draws in a single game, the minimum number of card draws to possibly win a game, and much more.

10:10–10:25

Fair Allocation Visualizations

Philip John Bontrager
Goshen College

Two or more people have equal ownership rights for several goods for which each person may have different monetary valuations. What is a fair way to allocate the goods among the people? This work examines different notions of fairness including efficient, proportionate, envy-free, share proportionate, and value proportionate. The goal is to develop visualizations to assist us and others to better understand notions of fairness and their interrelationships.

10:30–10:45

The “Bigger Half”: Examining Fair Division

Megan Chambers
Youngstown State University

The Fair Division Dilemma, also known as the “Cake-Cutting Problem”, is a method of resource allocation used to ensure that each party sharing the resource believes that they have received at least a fair share. It is a problem that has been studied extensively by mathematicians for years and has been the topic of many mathematical papers and books. In my presentation, I examine this problem and its many variations, as well as applications of the problem under different conditions. The potential uses for the problem are abundant, and the mathematics behind it are beautiful, not to mention delicious!

PME Session #5

Room: Meeting Room O **8:30A.M. – 11:45A.M.**

8:30–8:45

Sex-Dependent Deer Population Dynamics with Effects from Seasonal Harvesting

Shane Wilson
Luther College

We seek to formulate a sex-dependent population model for deer in Winneshiek County, aiming to determine the number of hunting licenses that should be issued in order to establish a stable population. Our assumptions are consistent with the life cycle of deer and the hunting licenses issued by the DNR.

8:50–9:05

Evaporation Investigation

Jacalyn Kulow
St. Norbert College

We will investigate various factors of water fountain evaporation in order to determine a more practical way of calculating the amount of water lost in these decorations. Through research and calculations, it is possible to gain a better understanding and draw conclusions as to how much water is being wasted.

9:10–9:25

From Golf Balls to Airplanes; What are the Powers of Dimples?

Erik Miller
St. Norbert College

Dimples are known to improve the performance of golf balls by extending the boundary layer over the surface. Could this principle be applied to airplane design? With the addition of dimpled airfoils, the performance of aircraft could be greatly improved. We'll investigate the aeronautical theory behind the dimples and see how it could affect the phases of flight.

9:30–9:45

Modeling the Population Dynamics of Phytoplankton in Freshwater Ecosystems

Jeff LaJeunesse
St. Norbert College

We investigate the population dynamics of phytoplankton, which form the base of aquatic ecosystems. Predicting phytoplankton growth contributes to a better understanding of climate change. We focus on how light availability, particle geometry, and fluid mixing affect changes in the population by using field data, laboratory data, and scientific computation.

9:50–10:05

Goursat's "Other" Theorem: A Complete Characterization of a Direct Products Subgroups

Daniel Catello

Youngstown State University

An elementary abstract algebra course teaches students many methods of constructing, analyzing, and dissecting groups. However, most texts and courses in this field exclude this intriguing theorem by Jean-Baptiste Goursat that fully characterizes the subgroups of a direct product. The theorem utilizes a surprising number of topics covered in a first abstract algebra course. Goursat's "other" theorem will be proven and dissected through some examples.

10:10–10:25

Significant Scientific Studies Made Aboard the International Space Station

Kathleen Karika

Texas A&M University

The ISS is a joint venture between five national space agencies whose goal is to discover in space what could otherwise never be determined from Earth. Using data analysis and mathematical modeling, a production function was developed to predict what influences a scientifically significant experiment.

10:30–10:45

Nesting Index for Assembly Words

Ryan Arredondo

University of South Florida

Ciliates are organisms which undergo massive recombination of DNA. A particular model for this recombination process uses structures called assembly graphs which can be represented by double occurrence words (assembly words). Patterns arise in the representations of certain scrambled genes. We use these patterns to define a nesting index for assembly words.

10:50–11:05

Outer Automorphisms of S_6

Mario Sracic

Youngstown State University

If G is a group, and $\phi : G \to G$ such that ϕ is one-to-one, onto, and a homomorphism, then ϕ is called an automorphism of G. Moreover, ϕ belongs to the group of automorphisms of G, denoted $Aut(G)$. Once defining the inner and outer automorphism groups, $Inn(G)$ and $Out(G)$), respectively; we will focus on proving

$$|Out(S_6)| \geq 2. \tag{1}$$

This theorem is necessary to show $Out(S_6) \cong \mathbb{Z}_2$. We will prove (1) through applications of group actions and the Sylow Theorems.

11:10–11:25

Mathematical Model for the Metabolic Pathway of the Butanol Fermentation

Estee George
Youngstown State University

The bacteria, *Clostridium beijerinckii*, ferment sugars to produce solvents like acetone, butanol, and ethanol for use as alternative fuels. The fermentation process can be modeled by a system of differential equations based on metabolic reactions using Michaelis Menten enzyme kinetics. The equations can be analyzed and numerically solved to explore the efficient conversion of glucose and xylose into butanol by these bacteria. The mathematical model predicts the concentrations of intermediaries and products formed, and results are compared to experimental data.

11:30–11:45

Science Fiction to Reality: The Influence of Interaction Rates, Flesh Decay, and Detection Rates in the Zombie Apocalypse

Frances Withrow
Texas A&M University

A zombie is considered to be the living dead, and of the realm of science fiction. However, in our generation zombies are commonly found in books, movies, and television shows. In this paper we use mathematical modeling to analyze a zombie outbreak. The ultimate goal was to develop a model that had a stable disease free equilibrium. We started with a previous model and developed new models that included concepts such as flesh decay, saturated interaction rates, and human detection rates. We included a sensitivity analysis of one of the new constants. None of the models had a stable disease free equilibrium; however, the most successful models were those that included some combination of saturation and detection rates. This implies that the best way to save humanity would be to decrease the number of humans a zombie can interact with and increase the rate of zombie detection per human being.

PME Session #6

Room: Meeting Room P **8:30A.M. – 11:45A.M.**

8:30–8:45

Nim on Groups

Marie Meyer
College of St. Benedict

The traditional game of Nim comprises of two players removing objects from distinct piles, and the player who takes the last object loses. We consider the game Nim on Cayley graphs of finite groups. We examine winning strategies for Nim on Cayley graphs of cyclic, dihedral, and abelian groups.

8:50–9:05

Investigation of Coloring Complexes in Hypergraphs

Nathaniel Kell
Denison University

One famous problem is the graph coloring problem: given a simple graph, what is the fewest number of colors required to color the vertices of the graph such that no adjacent vertices are the same color? It turns out that the number of λ-colorings of a graph G can be described by a polynomial $\chi_G(\lambda)$, referred to as the *chromatic polynomial* of G. Recent research has begun to establish relationships between $\chi_G(\lambda)$ and what is known as the *coloring complex* of G. In particular, we will be examining coloring complexes of *hypergraphs*—graphs where edges may connect more than two vertices.
For the research we conducted this past summer, we wrote a Sage program that computes information pertaining to the topology of the coloring complex and chromatic polynomial of an inputed hypergraph. We then attempted to use this data to make and prove conjectures about the relationships between these two objects. In this talk, we will formally define the above concepts, describe the capabilities of our program, and discuss the results we were able to establish.

9:10–9:25

Columnar Transposition Ciphers

Beth Bjorkman
Grand Valley State University

A columnar transposition cipher is an encryption technique that permutes the characters of a message using positions in a rectangular enciphering gird. In this project, we investigate the existence and location of fixed points of the underlying permutation as they relate to the number of columns and message length used.

9:30–9:45

Properties of Border Strips on Ferrers Diagrams

Luke Kressin
Hendrix College

This presentation examines relationships between visual representations of partitions, called Ferrers diagrams, and shapes called border strips. First, we examine the properties of border strips contained within Ferrers diagrams, then the properties of border strips appended to Ferrers diagrams, and finally the properties of border strips independent of Ferrers diagram.

9:50–10:05

Partially Ordered Sets of Commutative Catalan Interpretations and the Bivariate Catalan Generating Function

Heather Kitada
Lewis & Clark College

We will demonstrate several interpretations and bijections of sets of objects enumerated by the Catalan numbers: Dyck paths, rooted plane trees, binary trees, nonintersecting arcs, Temperley-Lieb Diagrams, and 312-avoiding permutations. Many of these objects are characterized by binary characteristics; however, we will also show more complex structures with applications in abstract algebra. Finally, we will explore single and bivariate Catalan generating functions that utilize statistics on Dyck paths, namely bounce and area.

10:10–10:25

A Generating Function for Inversions on Pattern Avoiding Involutions

Ashley Broadwell
Pepperdine University

The generating function for inversions on 312-avoiding permutations is given by the q-Catalan polynomial $C_n(q)$ and can be determined by using the area statistic on Dyck paths. In this talk, we will discuss the generating function for inversions on 312-avoiding involutions by using a certain subset of Dyck paths.

10:30–10:45

A Combinatorial Representation of Pattern Avoiding Involutions

Joshua Thornton
Pepperdine University

Permutations that avoid the pattern 312 are known to be counted by the Catalan numbers and can be represented combinatorially as Dyck paths. In this talk, we will discuss pattern avoiding involutions and give a combinatorial representation of these involutions as certain types of Dyck paths.

10:50–11:05

Fibonacci Numbers of Paths, Cycles and Combs

Emily Sasala
Washington & Jefferson College

The talk explores the Fibonacci numbers of paths, cycles and combs. The Fibonacci number of a graph corresponds to the number of independent vertex sets in that graph. We then discuss relationship between the Fibonacci number of cycles and the golden ratio and determine a recursive formula for combs.

11:10–11:25

Coloring the Platonic Solids

Danielle DeChellis
Youngstown State University

In this talk, we explore two different approaches to determining the number of ways to color the vertices of the Platonic solids. The first approach utilizes edge reduction and a matrix representation of the geometrical figures. The second approach implements traditional graph theory concepts to derive the chromatic polynomial. Both methods lead to the development of the chromatic polynomial, which is used to find the number of ways to color the vertices of the Platonic solids.

11:30–11:45

Mathematical Modeling of Selenium Metabolism in *S. maltophilia* ORO2.

Matthew Pierson
Youngstown State University

A system of differential equations was developed using a modified logistic growth equation coupled with Michaels-Menten enzyme kinetics to model bacterial growth and selenite metabolism in *S. maltophilia* ORO2. The model tracks selenite as it enters the cells and is reduced to nontoxic selenium. Analysis and numerical computation of the model compare favorably to experimental data, and help explain this bacterias resistance to selenite.

MAA Session #19

Room: Meeting Room K **2:00P.M. – 3:55P.M.**

2:00–2:15

The Effects of a Grace Period in a Multi-Stage Vaccine

Katherine Hunzinger
Benedictine University

Mathematical models are utilized to predict how a disease will spread and how to slow down its spread; this is important because it is unethical to test disease spread on a human population. We will be utilizing a model based on the SIR model to represent a disease's spread with the use of a multi-stage vaccine graphically and mathematically. Once we have found the proper parameters to represent the effectiveness and necessity of a multi-stage vaccine in order to eradicate a disease in a population, we can begin to analyze a few things. The goal of this project is to determine the effectiveness, or ineffectiveness, of a multi-stage vaccine when a controlled grace period is implemented amongst the population of study.

2:20–2:35

The Dynamics of an SVEIR epidemic model with Pulse Vaccination

Farina Kanwal
Benedictine University

We investigate the dynamics of an SVEIR model with pulse vaccination. We establish conditions based on the basic reproduction number, for which the model has a globally attractive infection free periodic solution and for which the disease persists.

2:40–2:55

Effects of a Dynamic Population in a Multi-Stage Vacccine

Kiran Munir
Benedictine University

Epidemiology calls for mathematical models to reveal results of hypothetical situations in order to slow the spread of disease. Unlike other branches of science, conducting an experiment by deliberately spreading disease to obtain results about the spread and the effectiveness of a vaccine would be unethical. Furthermore, some diseases require multiple shots with pre-determined time between them in order to be fully effective. In such a case, studying the effectiveness of vaccine in a given population saves resources while helping strategize the best usage of the limited vaccines. In this research project we will discuss instances for both a constant and a changing population.

3:00–3:15

Construction of Generalized Minimum Aberration Designs of size 36, 40 and 44

Laura M. White

Arkansas State University

Regular fractional factorial designs are widely used experimental designs for studying effects of two or more variable simultaneously, but leave large gaps in run size. Non-regular fractional factorial designs can be constructed for every run size that is a multiple of four, which allows run size flexibility and economy. My research will focus on construction of optimal designs of size 36, 40, and 44 runs using graphic processing unit (GPU) technology, with a primary objective of providing, for the first time, comprehensive design tables for the best 36, 40, and 44 runs designs available. Creating design tables make it possible for engineers and scientist to plan experiments for any combination of runs and number of variables to be studied.

MAA Session #20

Room: Meeting Room L **2:00P.M. – 3:55P.M.**

2:00–2:15

Security of a MAC Utilizing the Non-Associative property of Quasigroups

Natalia Poniatowska
Benedictine University

A Quasigroup is a set of elements with one binary operation whose multiplication table forms a Latin square. These algebraic structures are similar to groups; however they are not required to be associative. This non-associativity has many applications, one such area is Cryptography. A widely studied and used cryptographic tool is Message Authentication Code, MAC. In this talk I discuss a type of a MAC, called QMAC, which was introduced by Meyer. I will focus on properties of quasigroups including non-associativity and the generalized notion of non-associativity that can be used to better understand the security of this scheme.

2:20–2:35

Investigations into the Fixed Points of Group Automorphisms

Kingston Kang
Randolph-Macon College

The main purpose of this presentation is to prove a conjecture mentioned in the paper, On the Fixed Points of Abelian Group Automorphisms, published in Rose-Hulman Undegraduate Mathematics Journal 2010. In the paper, authors studied properties and developed formulae for θ, a function that records the order of each partition set of d-fixers $S_d^G = \{\alpha \in Aut(G) : |F_G(\alpha)| = d\}$, where d is a divisor of the order of an abelian group G. In the end of the paper, authors proposed a formula for groups of the form $\mathbb{Z}_p \times \mathbb{Z}_{p^2}$, where p is a prime, for all divisors d of $|\mathbb{Z}_p \times \mathbb{Z}_{p^2}| = p^3$.

2:40–2:55

Extensions of Finite Distributive Lattices

Tanya Riston
Penn State Erie, The Behrend College

A lattice is a partially ordered set where every pair of elements has a least upper bound and a greatest lower bound. Examples of distributive lattices include, but are not limited to, collection of open sets of a topological space and collection of ideals of a commutative ring. For a given distributive lattice L, the concepts of prime elements, $Spec(L)$, and minimal prime elements, $Min(L)$, of L are of great importance and can be used to understand various lattice-theoretic properties.

In this talk we will discuss the space of $Min(L)$ for a given finite distributive lattice L. Furthermore, using $Min(L)$ we will define various extensions of lattices, namely, rigid extension, r-extension, and $r^\flat$-extension, and results related to them. The ultimate goal is to answer an open question related to the extensions of finite distributive lattices: Is a rigid extension between finite distributive lattices equivalent to the r-extension?

3:00–3:15

3-rings and 3-fields

Brandon Alberts
Michigan State University

There are many results on the properties and classification of groups, rings, and fields. These have led to the solutions of many well known problems in mathematics, such as insolvability of the general quintic equation and the impossibility of trisecting a general angle. Rings and fields are extensions of the group structure to two operations rather than one with both operations jointly obeying the distributive law. The content of this talk will be extending these definitions to three operations rather than two creating structures called 3-rings and 3-fields. We will cover some results on classification and properties of these new structures.

MAA Session #21

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

2:00–2:15

Visualizing Chaos with Negative Alpha Values

Margaret Peterson
College of Saint Benedict

Based on previous work by Andrew Nicklawsky and Bob Hesse, instead of plotting iterative root finding methods on a subset of the complex plane, we have created a map utilizing a third dimension in which the initial starting point is plotted on the z-axis, creating 3D images of spheres. These spheres are shaded in accordance to the speed in which a particular initial starting point converged, allowing us to analyze convergence, or more specifically, to explore the choice of addition or subtraction in the denominator of the iterative root finding methods. There are many theories as to how the choice of sign shall be chosen for positive alpha values; however, in the case of a negative alpha value, these theories do not hold. Using programs based off of those developed by Nicklawsky, we developed rules to dictate this choice between addition and subtraction in order to maximize the speed of convergence for negative alpha values.

2:20–2:35

Invariants of Complex Hypersurfaces

Lukas Owens and Camilo Montoya
Whitman College and Florida International University

A complex analytic set is locally defined to be the set of common zeros of a number of analytic functions. The intricate properties of complex analytic sets are unique to several complex variables since in $\mathbb{C}$ any non-trivial complex analytic set is discrete.
In this talk we will study how properties of complex analytic sets that are naturally associated with a real-analytic hypersurface in $\mathbb{C}^n$ shed some light on the properties of the hypersurface itself.

2:40–2:55

Parametric Equations for Video Games

Benjamin Paul Studer
Augustana College

Danmaku, manic shooters, and bullet hell shooters are video game genres that feature intricate patterns of bullets that the player must avoid. The motion of the bullets is determined by parametric equations of varying complexity. After identifying the fundamental components of a Danmaku pattern, we will use a game engine to produce these patterns through the use of parametric equations primarily in the polar coordinate system.

3:00–3:15

Polylinear Spline Interpolation

Ryan Anderson
Kennesaw State University

Linear splines, in particular interpolating splines, are used to approximate a function given a discrete set of values of the function. Linear splines are widely used in many applications targeting geometric modeling of curves and surfaces as they are generally easy to work with, as the properties of linear functions are well known. The concept of linear splines have been extended to bilinear and polylinear splines with many results having been proved. In this talk, I will introduce the concept of spline interpolation and discuss simultaneous approximation of a function (of certain smoothness) and its derivatives by splines as well as present some results on the error of approximation.

J. Sutherland Frame Lectures

2012	Melanie Matchett Wood	*The Chemistry of Primes*
2011	Margaret H. Wright	*You Can't Top This: Making Things Better with Mathematics*
2010	Nathaniel Dean	*Incomprehensibility*
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

2012	Ivars Peterson	*Geometreks*
2011	Roger Nelson	*Math Icons*
2010	Sommer Gentry	*Faster, Safer, Healthier with Operations Research*
2009	Colm Mulcahy	*Mathemagic with a Deck of Cards on the Interval Between 5.700439718 and 806581751709438785716606368564037 66975289505440883277824000000000000*
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*

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