MAA Student Chapters

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

Pi Mu Epsilon

Pi Mu Epsilon is a national mathematics honor society with 389 chapters throughout the nation. Established in 1914, Pi Mu Epsilon is a non-secret organization whose purpose is the promotion of scholarly activity in mathematics among students in academic institutions. It seeks to do this by electing members on an honorary basis according to their proficiency in mathematics and by engaging in activities designed to provide for the mathematical and scholarly development of its members. Pi Mu Epsilon regularly engages students in scholarly activity through its *Journal* which has published student and faculty articles since 1949. Pi Mu Epsilon encourages scholarly activity in its chapters with grants to support mathematics contests and regional meetings established by the chapters and through its Lectureship program that funds Councillors to visit chapters. Since 1952, Pi Mu Epsilon has been holding its annual National Meeting with sessions for student papers in conjunction with the summer meetings of the Mathematical Association of America (MAA).

Schedule of Student Activities

Unless otherwise noted, all events are held at the Marriott Wardman Park.

Wednesday, August 5

Time:	Event:	Location:
11:45 am - 12:45 pm	CUSAC Meeting	Park Tower 8222
1:00 pm - 1:50 pm	The Jean Bee Chan & Peter Stanek Lecture for Students	Salon 2/3
3:00 pm - 5:00 pm	PME Student Check-In	Convention Registration
4:30 pm - 5:30 pm	Radical Dash	Salon 2/3
5:00 pm - 7:00 pm	MAA Centennial Reception	Exhibit Hall

Thursday, August 6

Time:	Event:	Location:
8:30 am - 11:30 am	PME Council Meeting	Delaware A
8:30 am - 10:25 am	MAA Session #1	Virginia A
	MAA Session #2	Virginia B
	MAA Session #3	Virginia C
	MAA Session #4	Wilson A
	MAA Session #5	Wilson B
	MAA Session #6	Wilson C
8:30 am - 10:25 am	PME Session #11	Delaware B
9:00 am - 5:00 pm	Student Hospitality Center	Exhibit Hall
1:00 pm - 1:50 pm	MAA Student Activity: Secrets of Mental Math	Salon 2/3
2:00 pm - 3:55 pm	MAA Session #7	Virginia A
	MAA Session #8	Virginia B
	MAA Session #9	Virginia C
	MAA Session #10	Wilson A
2:00 pm - 3:55 pm	PME Session #1	Wilson B
	PME Session #2	Wilson C
4:00 pm - 6:15 pm	MAA Session #11	Virginia A
	MAA Session #12	Virginia B
	MAA Session #13	Virginia C
	MAA Session #14	Wilson A
4:00 pm - 6:15 pm	PME Session #3	Wilson B
	PME Session #4	Wilson C

Friday, August 7

Time:	Event:	Location:
7:30 am - 8:30 am	PME Advisor Breakfast Meeting	*tba*
8:30 am - 11:45 am	MAA Session #15	Virginia A
	MAA Session #16	Virginia B
	MAA Session #17	Virginia C
	MAA Session #18	Wilson A
9:00 am - 5:00 pm	Student Hospitality Center	Exhibit Hall
8:30 am - 11:45 am	PME Session #5	Wilson B
	PME Session #6	Wilson C
	PME Session #12	Delaware B
2:00 pm - 3:55 pm	MAA Session #19	Virginia A
	MAA Session #20	Virginia B
	MAA Session #21	Virginia C
	MAA Session #22	Wilson A
2:00 pm - 3:55 pm	PME Session #7	Wilson B
	PME Session #8	Wilson C
2:35 pm - 3:55 pm	Non-Academic Career Paths Panel	Salon 1
3:30 pm - 5:00 pm	Estimathon!	Salon 1, Balcony A
4:00 pm - 5:00 pm	PME Session #9	Wilson B
	PME Session #10	Wilson C
6:00 pm - 7:45 pm	Pi Mu Epsilon Banquet	Virginia A, B, C
8:00 pm - 8:50 pm	Pi Mu Epsilon J. Sutherland Frame Lecture	Salon 2/3

Saturday, August 8

Time:	Event:	Location:
9:00 am - 12:30 pm	Student Hospitality Center	Exhibit Hall
9:00 am - 10:15 am	MAA Modeling (MCM) Winners	Salon 1
10:30 am - 11:45 am	Student Problem Solving Competition	Maryland B
12:30 pm - 2:00 pm	MAA Ice Cream Social and Undergraduate Awards Ceremony	Salon 3
1:00 pm - 5:00 pm	Great Talks for a General Audience	
	Part A	Virginia C
	Part B	Maryland C
	Part C	Salon 1 Balcony A
1:30 pm - 5:00 pm	Industrial Math Research in PIC Math Program	Maryland B

Jean B. Chan and Peter Stanek Lecture for Students

SEVENTY-FIVE YEARS OF MAA MATHEMATICS COMPETITIONS

Joseph Gallian
University of Minnesota Duluth

In this talk we provide facts, statistics, oddities, curiosities, videos, and trivia questions about the mathematics competitions that the MAA has sponsored for 75 years.

MAA Undergraduate Student Activity Session

SECRETS OF MENTAL MATH

Arthur Benjamin
Harvey Mudd College

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

J. Sutherland Frame Lecture

G-SHARP, A-FLAT, AND THE EUCLIDEAN ALGORITHM

Noam Elkies
Harvard University

Why does Western music almost universally use the same repeating pattern of 7+5 notes seen in the piano's white and black keys, and why does each of these notes (especially the black ones, like G-sharp / A-flat) get more than one name? Using a piano, the audience's voices, and more traditional lecture materials, I'll outline how music, physics, and mathematics converged to produce this structure, including an overlap between one thread of music history and the first few steps of the Euclidean algorithm applied to the logarithms of 2 and 3.

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.

Pi Mu Epsilon Speakers

Name	School	PME Session
Megan Alaimo	Western New England University	5
Michael A. Baker	Youngstown State University	5
Josiah M. Banks	Youngstown State University	2
Phillip Barbolla	Roanoke College	7
Steven Beres	Gonzaga University	12
Hayley Bertrand	St Norbert College	8
Matthew Buhr	University of South Dakota	3
Jasmine Burns	Eastern Washington University	4
Monica E. Busser	Youngstown State University	5
Aaron Calderon	University of Nebraska-Lincoln	12
Megan J. Chambers	Youngstown State University	3
Sharat Chandra	University of California, Irvine	6
Emma Christensen	College of St. Benedict/ St. John's University	12
Bryce Christopherson	Augustana College	8
Kadie Clancy	Washington & Jefferson College	8
Rebecca Claxton	Stockton University	12
Gregory Convertito	Trinity College	6
Jane Coons	State University of New York at Geneseo	2
Steven Dabelow	McNeese State University	5
Brian Darrow Jr.	Southern Connecticut State University	1
Niyousha Davachi	University of Texas at Arlington	5
Gary DeClerk	Hendrix College	4
Ryan DeElena	Texas State University	5
Matthew Devery	St. John's University	4
Robert Doughty	Miami University	11
Derek Foret	Kenyon College	7
Yu Fu	University of California, Irvine	3
Daniel Giles	Portland State University	6
Elliot Golias	Kent State University	6
Madeline Hansalik	Texas A&M University	5
Sarah Hilsman	Hope College	6
Jack Jenkins	State University of New York at Geneseo	2
Tianxia Jia	Winona State University	6
Edna Jones	Rose-Hulman Institute of Technology	12
Victoria Kelley	James Madison University	11
Douglas Knowles	State University of New York at Geneseo	2
Andrew Lacy	University of North Florida	6
Adelin Levin	Grand Valley State University	8
Yao Li	Winona State University	1

Pi Mu Epsilon Speakers (Continued)

Name	School	PME Session
Kate Lorenzen	Juniata College	4
Rayanne Luke	State University of New York at Geneseo	2
Crystal D. Mackey	Youngstown State University	3
Francis Mana-ay	Gonzaga University	1
John Mangles	Creighton University	7
Taylor McClanahan	University of Arkansas at Little Rock	3
Samuel McLaren	Western New England University	1
Andrew Nemec	Texas A&M University	7
William O'Brochta	Hendrix College	1
Samantha Parsons	Roanoke College	11
Sam Potier	St Norbert College	8
Sruti Prathivadhi	Creighton University	11
Megan Rodriguez	Hood College	9
Gili Rusak	Siena College	12
Jack Ryan	North Central College	5
Kristen Sandberg	Marist College	11
Michael Schroeder	St. Olaf College	4
Leah Seader	California University of Pennsylvania	10
Eric A. Shehadi	Youngstown State University	5
Lauren Snider	McNeese State University	12
Anna Snyder	Hope College	6
Samantha Stanley	Creighton University	1
Eric J. Stone	Youngstown State University	3
David Stoner	South Aiken High School	7
Kara Teehan	Stockton University	12
Nicole Trommelen	Sacred Heart University	12
John Tucker	State University of New York at Fredonia	6
Glce Sena Tuncer	Franklin & Marshall College	12
Gabrielle K. Van Scoy	Youngstown State University	3
John Vastola	University of Central Florida	6
AJ Vogt	Duquesne University	7
Cole Watson	Hope College	8
Jordan Weaver	Pepperdine University	10
Jessica Weed	Elon University	4
Zack While	Youngstown State University	5
Jenna L. Wise	Youngstown State University	2
Joshua Withee	Western Michigan University	9
Shuyan Zhan	Randolph-Macon College	11

MAA Student Speakers

Name	School	MAA Session
Soufiane Abbadi	Richland College	7
Mohammed Abdi	Benedict College	19
Ethan Ackelsberg	Bard College at Simon’s Rock	14
Emily Alfs	Doane College	17
Brandon Allen	Winona State University	19
Bethany Alloway	Morehead State University	5
Jing An	University of California, Los Angeles	22
Gabriel Arias	San Diego State University	11
Dylan Bacon	University of Wisconsin - Stout	12
Bethany Barber	Creighton University	19
Arash Barmas	Pierce College	18
Brennon Bauer	Southern Utah University	3
James M. Beaver	University of North Alabama	1
Robin Belton	Kenyon College	9
Aaron Berger	Yale University	17
John Berry	Williams College	12
Ryan Bianconi	Ithaca College	17
Subekshya Bidari	Trinity College	13
Ashley Blair	Brigham Young University	15
James Board	Radford University	1
Jonathan Boyd	Kent State University	17
David Brandfonbrener	Yale University	21
Daniel Branscomb	University of North Alabama	1
Michael Brown	Missouri Western State University	4
Matthew Buhr	University of South Dakota	3
Kyle Busse	Baylor University	19
Sean Callahan	Cal State Fullerton	10
Sean Callen	Missouri Western State University	4
Ian Cavey	Boise State University	2
Becky Chen	University of Richmond	9
Selene Chew	Rochester Institute of Technology	10
Christopher Chute	Yale University	17
Zachery Cole	Cedarville University	17
Jessica Copher	Shenandoah University	8
Angel Cortez	Western Connecticut State University	5
Elly Couch	University of North Alabama	22
Raemeon Cowan	University of Illinois at Urbana-Champaign	7
Levi Crews	Duke University	10
Michael Cruz	Borough of Manhattan Community College (BMCC) CUNY	3

MAA Student Speakers (Continued)

Name	School	MAA Session
Kaitlyn Cunanan	California State University, Fullerton	15
Yinlin Dai	Southwestern University	3
Matthew Dannenberg	Harvey Mudd College	12
Carl Dean	Duquesne University	18
Paul Diaz	Colorado School of Mines	20
Robert Dickens	University Of Maryland – Baltimore County	12
Garrett A. Divens	Morehouse College	10
Jordan DuBeau	Middlebury College	10
Kerry DuLaney	Ohio Northern University	7
Alexander J. Durbin	Michigan State University	17
Abigail Edgar	St. Edward’s University	6
Alex Edwards	University of North Alabama	1
Muhammad El Gebali	The American University in Cairo	17
Nermine El Sissi	The American University in Cairo	17
Marcus Elia	Geneseo State University of New York	17
Richard Elrod	Youngstown State University	18
Gereltuya Erdenejargal	University of Colorado Boulder	14
Marie Fallon	St. Catherine University	6
Bryan Félix	University of Texas at Austin	13
Manuel Fernandez	Florida International University	7
Hohite A. Fetene	Benedict College	19
Sarah Fleming	Williams College	1
Alexandra Fuchs	University of Texas at Dallas	16
Joseph Gaber	University of Michigan-Dearborn	18
Jason Gaitonde	Yale University	21
Peter Gartland	The Catholic University of America	20
Jonathan Gerhard	James Madison University	7
Alejandro Gomez	Hartnell College	9
Leah Granger	Clarkson University	18
Christopher Grimm	Brown University	8
Emma Groves	Southwestern University	3
Adam Grupa	Winona State University	6
Daniel Gulbrandsen	Utah Valley University	16
Elijah Gunther	Yale University	16
Derrick Gutierrez	California State University Fullerton	15
Katelyn Gutteridge	Missouri Western State University	4
Kareem Hamdan	University of Texas at Dallas	16
Colin Harrington	El Centro College	7
Janolin Higgins	Missouri Western State University	4
Tyler Hills	Brigham Young University	16

MAA Student Speakers (Continued)

Name	School	MAA Session
Tyler Hoffman	McDaniel College	16
Madison Hoffman	Kenyon College	9
Emily Hoopes	Youngstown State University	17
Emily Hubbard	Arkansas State University	15
Donald Hunt	Ohio Northern University	7
Natalie Hurd	West Chester University	14
Debra Ingram	Arkansas State University	15
Kinardi Isnata	Duquesne University	22
Emily Jaekle	Washington and Lee University	8
Lena Ji	Columbia University	1
Xinyi Jiang	Stanford University	8
Jiyi Jiang	Hope College	15
Iris Johnson	Morehead State University	5
Paul Johnson	West Chester University	14
Marjorie Jones	Pepperdine University	13
Eric Jones	Colorado School of Mines	20
Alex Kastner	Williams College	8
Elizabeth Kee	University of North Alabama	2
Greg Kehne	Williams College	8
Zander Kelley	Texas A&M	11
Abdullah Khan	University of Texas at Dallas	18
Caleb Ki	Amherst College	11
Benjamin Krakoff	Yale University	7
Prabhat Kumar	West Chester University	14
Susanna Lange	Grand Valley State University	17
Kristen Lawler	Marist College	9
Rachel Lawrence	Yale University	17
Hye Rin Lindsay Lee	California State University, Fullerton	15
Seung Hyun Lee	Yale University	21
Patrick Lenahan	Virginia Military Institute	15
Jason Liang	University of Chicago	12
Constanze Liaw	Baylor University	19
Efron Licht	San Diego State University	11
Caitlin Lienkaemper	Harvey Mudd College	13
Rizwan Maknojia	San Diego State University	11
Theresa Marlin	DeSales University	14
Julia Martin	SUNY Oswego	20
Oscar Martinez	Hartnell College	9
Lorin Matthews	Baylor University	19
James Matuk	Duquesne University	22

MAA Student Speakers (Continued)

Name	School	MAA Session
Nathaniel Mayer	Harvard University	8
Kayleigh McCrary	Agnes Scott College	14
Peter McDonald	Williams College	1
Ryan McDonnell	Washington and Lee University	8
Raymond McGinnis	Christian Brothers University	10
Elise McMahon	Ave Maria University	8
Mario Mendez	Hartnell College	9
Derek Miller	Brigham Young University	15
William Milligan	Emory University	13
Anita Mizer	Kent State University	19
Dario Molina	Hartnell College	9
Samantha Moore	University of Northern Colarado	12
Ryan Moore	San Diego State University	11
Shonell Moses	Marymount University	9
Sarah Mou	Illinois Math and Science Academy	2
Carlos Munoz	Texas A&M University	13
Zibusiso Ndimande	Benedict College	22
Maisie Newman	Washington College	9
Hieu Nguyen	Western Connecticut State University	5
Armin Niakan	Moorpark College	18
Stina Nyhus	Utah Valley University	16
Austin Oldag	University of North Alabama	1
Oliver Orejola	University of Colorado Boulder	14
Jason Orozco	San Jose State University	16
Jorge Flores Ortega	Hartnell College	9
Sean Owen	University of Maryland, Baltimore County	11
Eduardo Padilla	University of North Texas at Dallas	16
Alex Page	University of Illinois at Urbana-Champaign	2
Nina Pande	Williams College	1
Charlie Pasternak	Yale University	21
Luke Peilen	Yale University	17
Michael Perlman	University of Wisconsin - Stout	12
Carsten Peterson	Yale University	5
Robert Porter	Brigham Young University	16
Joshua Postel	University of Michigan-Dearborn	18
Sruti Prathivadhi	Creighton University	19
Ellen Prochaska	Creighton University	19
Melissa Riddle	California State University, Fullerton	18
Jennifer Robillard	Sacred Heart University	4
Laura Robusto	Virginia Wesleyan College	17
Gregory J. Rodriguez	New York University	10

MAA Student Speakers (Continued)

Name	School	MAA Session
Kristyn Roller	Asbury University	17
Asa Rubin	Trinity College	4
Alex Safsten	Brigham Young University	16
Jared Saltzberg	St. Mary’s College of Maryland	2
Juan Sancen-Bravo	Saginaw Valley State University	6
Chelsea Sandridge	Colorado School of Mines	20
Belina Santos	Arkansas State University	15
Taylor Schaben	Missouri Western State University	4
Blake Schildhauer	McDaniel College	11
David Schwein	Brown University	1
Tyler Searcy	Virginia Wesleyan College	17
Megan Searles	Brigham Young University	15
Huei Sears	Michigan State University	17
Yuliya Semibratova	University of Illinois at Urbana-Champaign	2
Erica Shook	Davidson College	4
Rachel Shore	Agnes Scott College	14
Katie Sipes	James Madison University	3
Alperen Sirin	University of Rochester	17
Cassandra Smith	San Diego State University	11
Jonathon Spaw	Millikin University	10
Travis Spillum	Saint John’s University	17
Mark Stahl	The University of Texas at Austin	11
Austin States	Virginia Military Institute	15
Kyle Steele	University of Central Oklahoma	21
Anna Steinfeld	St. Mary’s College of Maryland	2
Hailey Stirneman	Texas State University, Student	5
Matthew Stone	Yale University	17
Sean Suehr	Lake Superior State University	12
Tomoko Tachibana	Utah State University	11
Logan Tatham	Brigham Young University	18
Hriday Bharat Thakkar	Minot State University	21
Narayan Thapa	Minot State University	21
Jason Thoma	San Diego State University	11
Steven Tipton	New York City College of Technology, CUNY	15
Yen Nhi Truong Vu	Amherst College	11
Austin Unsicker	Brigham Young University	16
John Verdoza	California State University, Fullerton	15
Will Vosejpka	Amherst College	10
Matthew Wagerer	California State University, Fullerton	15
Nathan Wagner	Bucknell University	2
Timothy Warner	Vanderbilt University	10

MAA Student Speakers (Continued)

Name	School	MAA Session
Kirsti Wash	Trinity College	4
Noah Watson	James Madison University	14
Rebecca E. Wauford	Christian Brothers University	3
Aaron Westlake	Missouri Western State University	4
Lauren M. White	Smith College	7
Natalie Wolford	Brigham Young University	15
Victoria Wood	Agnes Scott College	14
Zev Woodstock	James Madison University	13
Bernadette Wunderly	Marymount University	9
Jiarui Xu	University of Illinois at Urbana-Champaign	15
Kan Xue	Borough of Manhattan Community College (BMCC) CUNY	18
Justina R. Yang	Yang Academy	19
Bowen Yang	Amherst College	11
Briana Yankie	Lee University	18
Mirroslav Yotov	Florida International University	7
Tessa Young	San Diego State University	11
Michael Zanger-Tishler	Yale University	21
Yingyi Zeng	St. Mary’s College of Maryland	12
Olivia Zhang	Yale University	16

Virginia A **8:30A.M. – 10:25A.M.**

8:30–8:45

Conditions on the Coefficients of a Factorable Cubic such that its Derivative is Factorable over the Rational Numbers.

James Board
Radford University

In this talk, the presenter will detail research conducted to develop a set of conditions on the coefficients of a cubic polynomial such that both and its derivative are factorable over the rational numbers. As a first step in this process an exploration of the conditions on the coefficients of a simplified cubic equation, , where each coefficient is a rational number, is conducted. The generation of sets of eligible coefficients which satisfy the required conditions is then made using MATLAB and highlighted in this talk.

8:50–9:05

Investigating Cardano's Irreducible Case

Alex Edwards and James M. Beaver
University of North Alabama

Solving cubic equations is a historically rich problem in mathematics. Unlike with quadratic equations, cubic equations do not have a "cubic formula." However, over the years many techniques have been presented that often find the solutions of cubic equations. Our research investigates one of these techniques known as Cardano's Method. This method provides an algebraic technique for solving the general cubic equation. Since its inception, this technique has suffered a significant drawback. In some instances, the application of Cardano's Method results in what Cardano termed the "irreducible case." The irreducible case occurs when a complex number is needed in order to complete the process. We are investigating the relationship among the coefficients of the general cubic equation and the irreducible case. We have determined that these relationships fall into one of three categories: always reducible, always irreducible, or conditionally irreducible. Through our research, we have discovered which relationships fall into each of the aforementioned categories. We are formulating a general algorithm to easily determine whether or not a given cubic equation will produce Cardano's irreducible case.

9:10–9:25

Sliding Disk Puzzles and Permutation Groups

Austin Oldag
University of North Alabama

We investigate sliding disk puzzles as a model for certain types of permutation groups. A general construction of puzzles whose arrangement isfinite abelian, symmetric, alternating, or direct products of these is presented.

9:30–9:45

Metric Distances Between Cayley Tables

Daniel Branscomb

University of North Alabama

We will use prior research to help put a metric between Cayley tables of finite cyclic groups. After discussing specific examples of lower orders and observing patterns to create a representation of the metric, we will examine an algorithm developed through C++ to simulate examples of higher order and show the representation holds.

9:50–10:05

A Metric for Local Rings

David Schwein and Nina Pande

Brown University and Williams College

A local ring is a Noetherian ring with exactly one maximal ideal. Using this maximal ideal, we can define a metric on the ring, and subsequently construct the completion of the metric space. This completion turns out to have interesting algebraic properties. In this talk, we will present results relating a local ring to its completion.

10:10–10:25

The Relationship Between a Local Ring and its Completion

Lena Ji, Sarah Fleming, and Peter McDonald

Columbia University and Williams College

Given a local ring R with maximal ideal M, its M-adic completion is also a local ring. The relationship between a ring and its completion, however, is not particularly well understood. In this talk, we will present original results that shed light on the relationship between a local ring and its M-adic completion.

Virginia B **8:30A.M. – 10:25A.M.**

8:30–8:45

Properties of Maximum Rhombi in a Triangle

Sarah Mou
Illinois Math and Science Academy

Consider the class of all rectangles contained in a triangle with one side lying on one side of the triangle. The rectangle in this class that has the maximum area will be called the maximum rectangle lying on the side of the triangle. Similar definitions apply to other types of quadrilaterals such as squares and rhombi. It is well-known that the three maximum parallelograms, which lie on the three sides of the triangle, respectively, have the same area. On the other hand, Calabi showed there is one and only one scalene triangle (up to similarity) with the same property that the three maximum squares lying on the three sides of the triangle have the same area. In this talk, we show that rhombi have the other extreme of the property by proving that the maximum rhombus in a triangle always lies on the shortest side of the triangle. Therefore, the maximum rhombi lying on the three sides of a scalene triangle must have different areas.

8:50–9:05

Poncelet Curves and Finite Blaschke Products

Nathan Wagner
Bucknell University

Poncelets closure theorem is a well-known geometric result concerning polygons that are inscribed in an ellipse and circumscribe a smaller ellipse contained in the larger one. Ellipses that can be so circumscribed are called Poncelet ellipses. On the other hand, Blaschke products are important analytic functions of a complex variable, because they are precisely the functions that are analytic on an open set containing the closed unit disk, map the unit disk to itself and the unit circle to itself. It turns out there is a deep connection between these functions and Poncelet ellipses. By examining properties of matrices representing the compression of the shift operator associated with the Blaschke product, we connect the compression of the shift, numerical range, Blaschke products, and Poncelet ellipses. This allows us to provide a new proof of a recent result due to Fujimura concerning necessary and sufficient conditions for a degree-4 Blaschke product to have an ellipse as its associated Poncelet curve.

9:10–9:25

Maps and Mirrors

Anna Steinfeld and Jared Saltzberg
St. Mary's College of Maryland

Gauss's Theorema Egregium implies that there is no local isometry between the sphere and plane. As a result, mapmakers have been forced to choose which geometric properties of the sphere they would like to preserve when creating images of the Earth, often at the cost of severely distorting others. In this presentation, we discuss how classical map projections can be induced by mirror surfaces, establishing new relationships between optical properties and cartographic ones.

9:30–9:45

Geodesics in the Heisenberg Group

Elizabeth Kee

University of North Alabama

In this talk, we will introduce a geometric visualization of a group, known as a Cayley graph, and define what it means for a word to be geodesic. Specifically, we will look at the Cayley graph for the Heisenberg group. Finally, we will discuss rules found to determine if a word is geodesic in the Heisenberg group.

9:50–10:05

**The Broken Stick Problem in Higher Dimensions:
From a Classic Puzzle to Modern Distance Geometry**

Yuliya Semibratova and Alex Page

University of Illinois at Urbana-Champaign

If a stick is broken up at two random points, what is the probability that the three pieces will form a triangle? This question, called the broken stick problem, first appeared about 150 years ago in an examination at Cambridge University. It attracted the interest of 19th century French probabilists, and more recently was popularized by Martin Gardner. In this presentation, we consider the generalization of this problem to three (or more) dimensions. In particular, if a stick is broken up at five random points, what is the probability that the six pieces will form a tetrahedron? Questions of this type arise in the field of distance geometry, which has connections areas such as wireless sensor networks and molecular biology. This is joint work with Yi Xuan and Eva Rui Zhang, conducted at the Illinois Geometry Lab (IGL) at the University of Illinois at Urbana-Champaign.

10:10–10:25

Volumes of Sphere-Bounded Regions in High Dimensions

Ian Cavey

Boise State University

What is the area of the centermost region formed by unit circle arcs centered at the vertices of a unit square? There are many ways to solve this high school level geometry puzzle, some of which suggest more general questions. What is the area of a similarly defined region with different regular polygons? What if we center spheres at the vertices of a cube or of a cube of arbitrary dimension. What happens to the volume of the centermost region as the number of dimensions gets arbitrarily large? A pleasing solution to the question asked of a regular n-gon, and a method to calculate the solution of the high dimensional case along with numerical solutions will be provided.

Virginia C **8:30A.M. – 10:25A.M.**

8:30–8:45

Dynamics of Ateles Hybridus Populations in Non-Fragmented and Fragmented Landscapes: A Discrete Mathematical Model

Matthew Buhr
University of South Dakota

Mathematical modeling is a branch of mathematics studying the behavior of systems and maps in a current state using past events. In this study, we create a mathematical model to estimate the dynamics of Ateles Hybridus, also known as the Brown Spider Monkey, in a non-fragmented and fragmented landscape. Typically, females give birth to only a single baby every one to five years. Young monkeys depend completely on their mothers for about ten weeks, but after that time they begin to explore on their own and play amongst themselves. Ateles Hybridus have undergone endangerment situations for several years. Our goal is to model the dynamics of Ateles Hybridus given their population structure and lifestyle. We first develop a single-patch model to model the dynamics of Ateles Hybridus populations in a single patch. Then, we consider a forced migration parameter of young females at the time of their sexual maturity and add new parameters into our single-patch model to account for differences in patch quality, given by hostility and by size. We take various parameters into account, including survival probabilities of every cohort of Ateles Hybridus, the birth gender probability, and the rate of reproduction. We aim to develop solutions to the endangerment issue, and provide feedback based on our mathematical model and testing.

8:50–9:05

Mathematically Modeling the Semipermeability of the Kidneys

Katie Sipes
James Madison University

The kidneys are an organ found on the dorsal side of the body and are responsible for fluctuating the salt concentrations in the blood plasma. The descending limb of the kidney is permeable to only water, so the water is taken out in an amount that is needed to remain in allostasis. The ascending limb is only permeable to salt and pumps salt out in order to make the medusa cortex salty. All of these processes can be modeled with simple differential equations to model how the kidneys produce a poetically perfect product that is your pee.

9:10–9:25

The Stability of a Semi-Implicit Numerical Scheme for Symbiotic Species

Brennon Bauer
Southern Utah University

Mutualism is the way two organisms of different species exist in a relationship in which each individual benefits from the activity of the other. We study a mathematical model of mutualism. The stability of the steady state solutions of this system will be analyzed. Also, we give some numerical experiments that verify the theoretical results for those steady solutions.

9:30–9:45

Simulating and Animating Spatial Interactions Between Species Living on a Torus with Given Population and Migration Dynamics

Michael Cruz
Borough of Manhattan Community College

This is a computational, population biology project, which aims at creating a computer simulation and animation based on a model of spatial interactions between species living on a torus. All simulations are coded using the programming language R and bundled into a video animating the spatial interactions based on given population and migration dynamics. The habitat for spatial interactions is modeled by a 2D lattice with periodic boundary conditions defined in a way that wraps the 2D lattice into a torus. The population dynamics is based on the Nicholson-Bailey family of models for coupled interactions between species, while the migration dynamics is based on the average inflow of migrating species from the nearest 8-neighbor migration zone for any given cell in the lattice. We will show an animation featuring the time evolution of the spatial interactions between the species living on a torus, revealing beautiful wave patterns.

9:50–10:05

Mathematical Modeling of a Zombie Apocalypse

Rebecca Wauford
Christian Brothers University

Humans Vs Zombies is a game that has gained popularity, especially on college campuses. At Christian Brothers University, the data collected from the game in previous years has not been conducive to mathematical disease modeling. This presentation will discuss the mathematical disease modeling applicable to a zombie apocalypse and the best rules to implement in the game in order for the data to trend appropriately. This presentation will also discuss how to best record data for the game in order to apply disease modeling.

10:10–10:25

Cholera as a Global Issue: Measuring the Effects of National Economic and Health Indicators

Emma Groves and Yinlin Dai
Southwestern University

Cholera is an infectious disease that has been a global health issue, particularly for South Asia and Africa. By using data from multiple countries, we compare associations between Cholera incidence rate and different economic and health indicators in order to produce mathematical models. People have a greater chance of getting cholera when they lack access to improved water and sanitation. We present various models, including simple and multiple regressions.

MAA Session #4

Wilson A **8:30A.M. – 10:25A.M.**

8:30–8:45

Scheduling a Tournament Using Graph Theory

Jennifer Robillard
Sacred Heart University

In this talk, we will discuss different methods that can be used to schedule a round robin tournament. We will then utilize a theorem to apply to tournaments of all sizes. We will look at the complications that arise when trying to schedule a tournament through guessing. Then, we will see some simple methods that work best for putting together a tournament with a smaller number of teams, and also at methods that can be used for any tournament, no matter how large. We will utilize graphs in order to represent both whole tournaments as well as single rounds in the tournament. We will look at two different tournament constructions: the Kirkman and the Steiner. Finally, we will see a brief overview of different factors to consider when scheduling any round robin tournament.

8:50–9:05

On Counting Special Classes of Directed Graphs and Their Generalizations

Janolin Higgins and Michael Brown
Missouri Western State University

In the context of synthetic biology, our undergraduate research team explored discrete search algorithms. Building on the results from a previous year, our team verified and extended known results on Limited Outdegree Grid (LOG) directed graphs and Greatest Increase Grid (GIG) directed graphs.

9:10–9:25

Sorting Problems: Results and Directions

Aaron Westlake
Missouri Western State University

In the context of a synthetic biology project, our undergraduate research team will explore a variety of sorting problems. Results of this investigation and suggestions for future directions will be presented.

9:30–9:45

Hidden Markov Models and Synthetic Biology

Sean Callen
Missouri Western State University

During the summer of 2014, math students worked alongside biology students to learn and understand Hidden Markov Models. In Summer of 2015, we will work to apply HMM to the modeling of bacterial DNA to optimize orthogonal metabolism in E. coli.

9:50–10:05

Programmed Evolution and the Design of New Aptamers

Katelyn Gutteridge, Taylor Schaben, and Erica Shook
Missouri Western State University and Davidson College

Programmed Evolution is the process by which bacteria are encouraged through manipulation of their DNA and their environment to produce optimal amounts of a desired metabolite. As an example, our team developed a proof-of-concept system in E. coli to convert caffeine to theophylline. In this talk, we describe the overall concept of Programmed Evolution and the interplay between the mathematics and biology halves of our team as we seek to design new aptamers, a key to the process.

10:10–10:25

Domination in the Generalized Hierarchical Product

Asa Rubin and Kirsti Wash
Trinity College

In 2008, Barrière et al. introduced the hierarchical product of graphs which is a generalization of the well-known Cartesian product of graphs. Given a graph G, a set $S \subseteq V(G)$ is said to be a dominating set if every vertex in $V(G) - S$ is adjacent to a vertex of S. The minimum cardinality of any dominating set of G is referred to as the domination number of G, and denoted $\gamma(G)$. Motivated by Vizing's Conjecture that $\gamma(G \Box H) \geq \gamma(G)\gamma(H)$, we would like to find a lower bound for the domination number of any hierarchical product in terms of $\gamma(G)$ and $\gamma(H)$. In this talk, we give preliminary results on the domination number of specific types of hierarchical products.

8:30–8:45

No Talk

Speaker Canceled

NA

8:50–9:05

No Talk

Speaker Canceled

NA

9:10–9:25

Nonattacking Queens on a Torus Chessboard with Pawns

Bethany Alloway and Iris Johnson

Morehead State University

The $N+K$ Queens Problem is a Graph Theory problem that requires the placing of N Queens and K Pawns on an $n \times n$ chessboard in such a way that no two Queens attack each other. Recently, we have been exploring an expansion of this problem by placing non-attacking Queens and Pawns on an $n \times n$ torus. We will be discussing patterns that we have found on certain boards and how we plan to implement them in a computer program designed to solve any board size.

9:30–9:45

Improvements on the Generalized Numerical Semigroup Tree Algorithm

Carsten Peterson

Yale University

Failla, Peterson, & Utano (2015) re-introduced the notion of a generalized numerical semigroup as a cofinite submonoid with identity of $\mathbb{N}_0^d$. They generalized much of the existing theory of numerical semigroups; notably they provided a generalization of the semigroup tree algorithm of Bras-Amoros (2008). We greatly improve the time complexity of the algorithm of Failla et al., implement this algorithm, and enumerate all numerical semigroups of small genus and dimension. We further generalize many of the existing results from the theory of numerical semigroups. We demonstrate a bijection between idempotent elements of the symmetric semigroup and full rank hole sets of genus $g = d$. We provide bounds on the growth rate of the number of generalized numerical semigroups of fixed dimension and increasing genus.

9:50–10:05

M-Band Wavelet based Pseudo Quantum Encryption

Hieu Nguyen and Angel Cortez
Western Connecticut State University

In the modern digital era, data security has become essential. Whether this data is from a government, a large corporation, or a citizen, the right of privacy should be protected. Due to recent development in Quantum computing and Wavelet Analysis, we propose a wavelet based Pseudo Quantum encryption scheme to enhance the protection of privacy among all users of the internet. Our algorithm transforms the data using pseudo quantum computation in the M-band Wavelet domain. Assured by Heisenberg's uncertainty principle and the no-cloning theorem, this encryption method will make the data incredibly difficult to decode without the proper key.

10:10–10:25

Position Estimation from Angles and the Tropical Condition Number

Hailey Stirneman
Texas State University

Suppose you are in space and you know the position of three planets. Suppose further that there is no plane containing you and all the planets (which in fact happens with high probability), and that you can measure the angle between any two planets from your position. We show how estimating your position can be reduced to polynomial system solving, and study the maximal number of real solutions for the underlying system. Furthermore, we study the numerical conditioning of the underlying polynomial system, i.e., the sensitivity of solutions to perturbation of the input parameters. Knowing precise estimates on numerical conditioning is vital in applications, since spacecraft operate at great speed and large scale distances where sensor uncertainty can cause severe errors. Moreover, since computers on spacecraft have to be made with circuits resistant to radiation, their microprocessors are usually slower and thus algorithmic efficiency is crucial. In particular, if a calculation takes too many fractions of a second, one can be miles away from one's measured position. Finally, planets in nearby orbit planes can also result in ill-conditioned polynomial systems. We will examine these issues, focusing on our own solar system. We also use a new estimator for the condition number based on the underlying Archimedean tropical varieties.

8:30–8:45

No Talk
Speaker Canceled
NA

8:50–9:05

No Talk
Speaker Canceled
NA

9:10–9:25

Analysis and Inference of Cygnus Machine Diagnostics

Adam Grupa
Winona State University

Cygnus is a flash X-ray generator used by National Security Technologies at the Nevada National Security Site to record images of subcritical nuclear experiments in support of the U.S. Stockpile Stewardship program. Experiments performed with Cygnus are expensive and must be scheduled far in advance, so it is critical Cygnus performs correctly during each experiment. However, the process used to determine the usability of an experiment takes several hours. During the course of an experiment, machine diagnostics are collected from electrical sensors along Cygnus. These diagnostics are available immediately, so it would be useful if experiment usability could be determined from them. We analyze these electrical diagnostics using signal processing techniques to determine characteristics that exist in the signals, and then use those characteristics to create a predictive model that allows us to infer the usability of an experiment.

9:30–9:45

Identifying Fries and Clar Numbers for Special Benzenoids

Marie Fallon
St. Catherine University

Benzene is an important structure in chemistry due to its stability and the stability it can provide to a molecule. A benzene ring is formed out of six carbon atoms with alternating single and double bonds and one hydrogen atom bonded to each carbon atom, which can easily be modeled by a hexagon with a perfect matching superimposed. Benzenoids are molecules with benzene-like properties which can be modeled by a grid of hexagons called a hexagonal system. Rispoli showed the number of perfect matchings for five specific classes of benzenoids. The Fries number of a hexagonal system is the maximum number of benzenes in a perfect matching of the system while the Clar number of a hexagonal system is the maximum number of benzenes in a perfect matching of the system so that no two benzenes share edges. The Clar and Fries numbers are significant due to their correlation with stability of the molecule. We investigated the Fries and Clar numbers for the five hexagonal systems defined by Rispoli. We determined both the Fries and Clar number for each of the five systems as well as finding the number of structures that realize the Fries and Clar numbers. Although Clar and Fries numbers can be computed with linear programming, these theorems are a much faster way to find them.

9:50–10:05

An Investment Model for Superior Risk-Adjusted Returns

Juan Sancen-Bravo

Saginaw Valley State University

Most people buy stocks hoping for the price to go up, but what about when you think the stock price will go down? This model was developed similar to a long/short hedge fund investment model for people with a low risk appetite through the use of a market neutral strategy, which protects returns from adverse market movements. The model is designed to counter the effects of large losses while still generating satisfactory risk-adjusted returns. During periods of high volatility, we expect the model to perform its best and demonstrate its effectiveness. Through the use of statistical and fundamental value analysis, we pair long and short stock positions to neutralize the effects of systematic risk; moreover, through various heuristic techniques this model is unique in regards to its stock selection guidelines and criteria. Over the last 3-year and 5-year periods the model achieved a 15% and 17% annual return with a fraction of the market risk, which compares well to the S&P 500. Also, through a separate portfolio simulation the model achieved a 1.5% monthly return in the first three months since its creation. The 2008 financial crisis blatantly exposed the need for better risk measures to protect returns, and this model is designed, and is continuously evolving, to counter these effects. Due to its risk-adjusted nature, the research model is expected to be used to help the Saginaw Valley State University community in the form of student scholarships.

10:10–10:25

Minimum Agreement Proportion in Box Societies

Abigail Edgar

St. Edward's University

We study the minimum agreement proportion guaranteed by approval voting techniques in societies in which two out of any three voters have overlapping opinions on two issues, i.e., $(2,3)$-agreeable societies where voters' opinions can be graphically represented by two-dimensional boxes (one dimension for each issue). While the current greatest lower bound on agreement proportion in such societies is $1/4$, the lowest known example exhibits a greater agreement proportion of $3/8$. Thus, we focus on whether the lower bound $1/4$ is sharp by attempting to produce such an example or by showing why such an example is not possible and then improving this lower bound. We approach this combinatorial problem by using techniques from graph theory and Ramsey theory to scrutinize the intersection graphs representing our $(2,3)$-agreeable box societies.

Virginia A **2:00P.M. – 3:55P.M.**

2:00–2:15

Counting Subrings of a Finite Ring

Benjamin Krakoff
Yale University

Given a finite commutative ring (with unity), a natural question to investigate is its subring structure. For many problems, it's enough to assume the ring is a finite abelian p-group, and to consider subrings of a fixed index. In the case of finite abelian groups, the subgroup structure is a classical subject; an important contribution was made by P. Hall who introduced a family of polynomials that count these objects, now called Hall polynomials. These in turn have important connections with representation theory and symmetric functions. However, there aren't many general results for finite commutative rings, so the task is to focus on some important examples that arise and which already hint at the rich structure present. We'll present some general basic results on this counting problem, and compare how the multiplicative structure of the ring restricts the possible subrings allowable. For some concrete classes of finite rings, we obtain explicit bounds for the number of subrings, which display an interesting behavior.

2:20–2:35

Conjugacy Classes of $\mathbf{GSp(2n, p)}$

Jonathan Gerhard
James Madison University

The finite matrix group $GSp(2n, \mathbb{F}_q)$ is the subgroup of $GL(2n, \mathbb{F}_q)$ consisting of matrices that preserve an antisymmetric bilinear form up to scalar multiple. In $GL(2n, \mathbb{F}_q)$, the characteristic polynomial and some additional partition data completely determine a conjugacy class. However, in $GSp(2n, \mathbb{F}_q)$, this is still not enough to uniquely identify a conjugacy class in every case. For $n = 3$ and 4, we use a parameterization of Shinoda (1980) to construct representatives of all conjugacy classes over $\overline{\mathbb{F}_q}$, and then use the representatives to determine the sizes of those conjugacy classes. In this talk, we will present some of our results, the techniques used to gather those results, and a connection to the dimensions of certain matrix group representations.

2:40–2:55

Exploring Mathematics in Gears and Watchmaking

Kerry DuLaney and Donald Hunt
Ohio Northern University

The basis of this project was to explore mathematics linked to gears and watchmaking. The topics investigated include Ford circles and trees, the Stern-Brocot tree, Euclid's algorithm, Farey addition, Fibonacci sequences, matrices and continued fractions. Using these techniques we were able to navigate the Stern–Brocot tree by replicating rows and determining term placement within rows.

3:00–3:15

The Ubiquitous Fermat Primes

Manuel Fernandez and Mirroslav Yotov
Florida International University

Fermat prime numbers have a rich history, and are known to play important roles in a variety of situations in mathematics. We are explaining yet another, quite unexpected, appearance of the Fermat prime numbers in the context of generalizing Wilson's theorem from classical Number Theory. We prove our results by using methods from elementary Number Theory, the theory of finite Abelian groups, and the ring of polynomials with coefficients in the ring of integers modulo n.

3:20–3:35

A Better Approximation for the nth Prime

Colin Harrington and Soufiane Abbadi
El Centro College and Richland College

By using Cipolla's asymptotic expansion for the nth prime, the merits of an enhanced corresponding integrated approximation will be shown. A basic understanding of both the density and approximations for prime numbers will be used to manipulate and create an integral and transform it into a model that will reduce the error of approximation. By using both MATLAB and stochastic analysis, we will compare the classical model of approximation to the new family of functions for successive groupings of prime integers. The resulting model will show the best fit for the approximation of the nth prime.

3:40–3:55

The Igusa Zeta Function of a Quadratic Polynomial over a p-adic Field

Raemeon Cowan and Lauren M. White
University of Illinois at Urbana-Champaign and Smith College

Let $f(x_1, \ldots, x_n)$ be a quadratic polynomial over the ring of integers, R, in a p-adic field, K. Let π be a uniformizer of R and q be the order of the residue field $R/\pi R$. Let $N_i(f)$ be the number of zeroes of f modulo π^i. The Poincare series, $P_f(t) = \sum_{i\geq 0} \frac{N_i(f)}{q^{in}} t^i$, is a power series that organizes these zero counts. From the Poincare series one can obtain the Igusa zeta function using the relation $Z_f(s) = q^s - (q^s - 1)P_f(q^{-s})$. For s in the complex right half-plane, the Igusa zeta function is defined to be $Z_f(s) = \int_{R^n} |f(x_1, x_2, \ldots, x_n)|_\pi^s dx_1 \ldots dx_n$, where $|\cdot|_\pi$ is the p-adic absolute value and $dx_1 \ldots dx_n$ is a volume element (for Haar measure). We calculate the Poincare series and the Igusa Zeta function for an arbitrary quadratic polynomial over R using a new form of generating function. When p is an odd prime, our results agree with those of Igusa, and our results when $p = 2$ are new.

2:00–2:15

Mathematics and 3D printing

Ryan McDonnell and Emily Jaekle

Washington and Lee University

In calculus, it can be difficult to visualize and draw volumes of solids computed using disk and cylindrical shell methods, among others. These volumes can be modeled using a 3D printer. The 3D printer is a also useful tool in multivariable calculus because it can be used to build models of quadratic surfaces such as cones, paraboloids and hyperboloids. Finally, more complex topological objects such as tori, Mobius strips, and knots can be printed. The mathematical objects are first created through Mathematica or Maple, and are then converted to a 3D model in a format which can then be read by a 3D printer. There are interesting mathematical and computational challenges in creating the models.

2:20–2:35

Methods for Relating Symmetric and Antisymmetric Canonical Algebraic Curvature Tensors

Elise McMahon

Ave Maria University

We are interested in relating canonical algebraic curvature tensors that are built with a self-adjoint linear operator, R_A^Λ, to those built with a skew-adjoint linear operator R_A^S, as the space of algebraic curvature tensors is spanned by both types separately. By Nash's imbedding theorem, an algebraic curvature tensor with respect to a symmetric tensor is realizable as an embedded hypersurface in Euclidean space. We develop an identity to relate the skew-adjoint canonical algebraic curvature tensor to the self-adjoint canonical tensors, allowing for a more restrictive dependence of the curvature tensor on the operator. We prove that the structure group of R_A^Λ is equivalent to the structure group of A up to a sign. Using this relationship we develop methods for determining the linear independence of sets which contain both builds of algebraic curvature tensors. We consider cases where the operators are arranged in chain complexes and we find this case to be highly restrictive. Moreover, if one of the operators has a nontrivial kernel, we develop a method for reducing the bound on the least number of canonical algebraic curvature tensors that it takes to write an algebraic curvature tensor.

2:40–2:55

Solutions of the Inverse-Square Brachistochrone Problem

Christopher Grimm
Brown University

The classic Brachistochrone Problem is the following: given two points A, B lying in a plane construct a smooth (frictionless) curve connecting A to B that minimizes the time of flight for a particle sliding under the influence of a uniform gravitational field. In this talk we consider the general problem of finding time optimal paths in inverse square gravitational fields. We will show that the classic approach of using smooth solutions to the Euler-Lagrange equations fails for a large range of values of A and B. However, by considering an appropriate "weak notion of solutions we show that the time optimal paths consist of piecewise continuous solutions to the Euler-Lagrange equations that are not differentiable in the classical sense. We will conclude with an exploration of how these non-smooth solutions can be realized as limiting curves for a relaxed version of the problem.

3:00–3:15

Sums and Products of Squared Diagonal and Edge Lengths of Regular Polytopes

Jessica Copher
Shenandoah University

Polytopes are the n-dimensional generalization of polygons and polyhedra. Although an extensive literature review uncovered a number of theorems involving diagonal lengths of regular polytopes, it found no investigations concerning whether any of these theorems define relationships that might generalize to *all* of the diagonals of *all* regular polytopes. Consequently, this talk will explore whether one area of previous study—viz., the four theorems relating to the sums and products of squared diagonal and edge lengths of regular polygons inscribed in unit circles—can be generalized to all regular, n-dimensional polytopes inscribed in unit n-spheres. We will see (a) that one of these theorems does, in fact, generalize to all regular, n-dimensional polytopes; (b) that a second one generalizes to all regular, n-dimensional polytopes except the family of simplices and the odd-edge polygons, and (c) that attempting to generalize these four theorems to n dimensions yields several other interesting results.

3:20–3:35

When is a Knot Hyperbolic?

Nathaniel Mayer
Harvard University

A knot is hyperbolic if it complement has a hyperbolic metric. When that is the case, powerful geometric invariants can be applied to analyze the knots. It is known that prime alternating knots other than 2-braids are hyperbolic. We consider hyperbolicity for other families of knots.

3:40–3:55

Totally Geodesic Surfaces in Hyperbolic Knot Complements

Xinyi Jiang, Alex Kastner, and Greg Kehne

Stanford University and Williams College

Surfaces in the complements of knots have long been used to analyze knots. A particularly nice class of surfaces is totally geodesic surfaces, which lie in the complement in a particularly nice way. We consider ways to generate such surfaces and their generalizations.

Virginia C **2:00P.M. – 3:55P.M.**

2:00–2:15

Lyapunov Function Arguments for Global Stability in Compartmental Epidemiological Models

Kristen Lawler
Marist College

In 2004, Korobeinikov was the first to use a Lyapunov function argument to prove the global stability of the disease-free and endemic equilibria in the susceptible-exposed-infectious-removed (SEIR) model in mathematical epidemiology. One feature of his proofs included an appeal to the superiority of the arithmetic, over the geometric, mean. In this talk, we will revisit his arguments, and discuss avenues of approach to establish further results using Lyapunov functions.

2:20–2:35

Parameter Choice and Optimal Control Advice for West Nile Virus

Bernadette Wunderly and Shonell Moses
Marymount University

This research builds on a model for West Nile Virus that uses optimal control theory to determine cost-effective strategies to reduce the seasonal spread of disease. This research project explores how parameter variation impacts control advice for resource management officials. For example, how might climate variation change our approach to controlling West Nile Virus? Additionally, although nestling vaccination is an untried and expensive strategy, do our simulations suggest that the effort is warranted? Are model parameters selected as important in a Latin Hypercube Sampling / PRCC sensitivity analysis the only parameters that are important to the question of control? We work with a complex age-structured avian / mosquito model and consider much parameter variation to provide a thorough analysis for the questions above.

2:40–2:55

A Comparative Exploration in Placental Imaging

Robin Belton and Madison Hoffman
Kenyon College

In recent years, research in the field of placental analysis has demonstrated connections between placental features, such as shape and vascular structure, to the health and development of newborn babies. In an attempt to improve automation of vascular-structure extraction, researchers and medical practitioners have injected placental veins and arteries with colored dye. During the process of dye-injection, placental characteristics may be altered. Using a data set consisting of 11 placentas, we aim to determine the level of similarity between hand-drawn tracings of the vascular structure of placental images before and after dye-injection. In this talk, we present explorations of various measures of similarity. Initial findings suggest that some important features of placental structure are preserved throughout the process of dye-injection.

3:00–3:15

Mathematical Modeling, Analysis and Control of the Antibiotic Resistant Infections CRE

Mario Mendez, Alejandro Gomez, Dario Molina, Oscar Martinez, and Jorge Flores Ortega
Hartnell College

Antibacterial resistance is a serious and growing threat to hospitalized patients, and is predicted to become a global crisis. Infections caused by carbapenem-resistant Enterobacteriaceae (CRE) have been associated with high mortality rate (30% to 72%), and have demonstrated resistance to many other classes of antibiotics. Therefore, with limited treatment options and the scarcity of new antibiotics in the pharmaceutical industry's pipeline, examining strategies to efficiently prevent and control those infections is becoming critically urgent (CDC). The aims of this project include the use of robust mathematical modeling tools to understand and simulate the mechanism underlying the emergence in hospitals of CRE, and determination of efficient and cost effective control strategies that incorporate up-to-date special preventive measures, as well as validation of the models using clinical data and identification of critical parameters without the risk and cost involved in a widespread clinical testing.

3:20–3:35

A Genetic Algorithm Approach to the Control of West Nile Virus

Maisie Newman
Washington College

This research builds on a model for West Nile Virus that uses optimal control theory to determine cost-effective strategies to reduce the seasonal spread of disease. We wish to consider an alternative method for optimization: genetic algorithms (GA). The GA approach to optimization applies principles mimicking genetic evolution to create optimal strategies for the control of West Nile Virus. Through GA we are able to construct advice that is more consistent with the use of pesticides that is allowed in the field, and that can account for costs and budget ceilings in a more realistic manner than in our current optimal control formulation. The purpose of this research is to determine if the more computationally-intensive GA (1) provides consistent results with optimal control theory when provided similar constraints, and (2) can ultimately provide more realistic advice to resource management officials.

3:40–3:55

Mathematical Modeling of a 4-by-4 Nematode-bacteria Predator-prey System

Becky Chen

University of Richmond

The foraging behavior of bacterial-feeding nematodes is investigated using agent-based and differential equations-based modeling. Our goal is to simulate a "nematode world," namely the nematode-bacteria predator-prey system, as it would appear in a cubic foot of soil. We focus on two main search strategies: chemotaxis, where the searcher moves upward or downward along a chemical concentration gradient, and infotaxis, where the searcher moves in the direction that allows it to maximize the amount of information it gathers about the location of the food source. In order not to violate the competitive exclusion principle, which states that two species that compete for the exact same resources cannot stably coexist, we propose a predator-prey model that consists of two different species of bacterial-feeding nematodes, one with a specialist diet and one with a generalist diet, and two different species of bacteria, one that is preferred and one that is acceptable to the generalist diet. Parameters we incorporate into our model include soil moisture, reproduction rate, moving speed, nematode sensitivity to bacterial chemical concentration gradients, and energy level changes due to movement and reproduction. We obtain accurate values for our parameters by reading previous literature and conducting biological experiments that involve tracking nematode movement through video imaging and observing the different search strategies of nematodes. Similar to other models on population dynamics, we expect that (in the agent-based model) the populations of all four species will oscillate stochastically about a stable limit cycle trajectory in phase space.

3rd Floor, Studio Suite **2:00P.M. – 3:55P.M.**

2:00–2:15

Solving a limitation of the Rook problem

Raymond McGinnis
Christian Brothers University

The Rook problem is a question based on the allowable moves by rooks in chess. This presentation attempts to find an algorithm to solve a limitation of the non-attacking Rook problem. For our problem, only a square board ($n \times n$) will be used, and each piece is placed at an origin that attacks m spaces vertically and horizontally from the origin, where $m \leq n$. We also consider the case where the origin point is offset. In both cases we say a piece attacks if the entire attack region is on the board.

2:20–2:35

A Graph Theoretic Approach to the Character Admissibility Problem in Referendum Elections

Selene Chew and Timothy Warner
Rochester Institute of Technology and Vanderbilt University

In referendum elections, voters are often required to cast simultaneous votes on multiple questions or proposals. The separability problem occurs when a voter's preferences on the outcome of one or more proposals depend on the predicted outcomes of other proposals. The character of a voter's preferences describes the interdependence relationships (for that voter) between the sets of proposals in the election. While it is easy to determine the character of a voter's preferences, the inverse problem—that is, finding a voter whose preferences have a given, pre-determined character—is much more challenging. In this talk, we will describe a graph theoretic approach to character construction, defining the character spectrum of a graph and investigating related theoretical and computational results. This work was completed as part of the Summer Mathematics REU at Grand Valley State University.

2:40–2:55

Locating Sets and Numbers for Disconnected Graphs

Jonathon Spaw
Millikin University

According to Pirzada et. al, the locating code of a vertex v in an undirected graph $G(V, E)$ is a finite vector representing distances of v with respect to vertices in an ordered subset W of $V(G)$. We call W a locating set if each vertex in the graph has a distinct locating code and call the number of vertices in the minimal locating set the locating number. Most of the work pertaining to locating sets has depended on the assumption that $G(V, E)$ is connected. We have designed and implemented an algorithm using Sage to compute locating numbers and locating set for any connected or disconnected graph. Additionally, we present results related to the locating numbers of general disconnected graphs as well as conditions for locating sets of disconnected graphs. Furthermore, we present a generalized characterization result for particular locating numbers.

3:00–3:15

Cops and Robbers in Tunnels

Levi Crews and Will Vosejpka

Duke University and Amherst College

Cops and Robbers is a perfect information, vertex-pursuit game played on a finite reflexive graph G. Two players, a set of cops C and a robber R, begin by occupying vertices in G. The players then alternate moves (C then R), either moving along edges or passing. The cops win if at least one cop can move to the same vertex as the robber in a finite number of moves (called *capture*). Otherwise the robber wins. The cop-number, denoted $c(G)$, is the minimum amount of cops needed to guarantee that the robber is captured. A graph G is called copwin if $c(G) = 1$. Let G and H be graphs and let $v \in V(G)$ and $u \in V(H)$. We form a graph T such that $V(T) = V(G) \cup V(H)$ and $E(T) = E(G) \cup E(H) \cup \{v, u\}$. We call $\{v, u\}$ a tunnel. We will present progress towards classifying the graphs G and H such that $c(T) = max\{c(G), c(H)\}$.

3:20–3:35

Double Pitfalls and Copnumber Two Graphs

Jordan DuBeau, Gregory J. Rodriguez, and Garrett A. Divens

Middlebury College, New York University, and Morehouse College

Consider a finite connected graph G. The game of Cops and Robbers is played on G with two players C and R. C first places her cop(s) on the graph and then R places his robber on the graph. The two players alternate turns (C and then R) by either moving any number of their pieces to an adjacent vertex or staying still. C wins if a cop occupies the same vertex as R and R wins if he can always avoid capture. The copnumber of a graph refers to the fewest number of cops that are necessary for C to win. We explore the idea of a "double pitfall," which is a vertex that is dominated collectively by two other vertices. We demonstrate how this idea can help towards characterizing copnumber two graphs, including a possible algorithmic approach to the characterization.

3:40–3:55

Identifying Gender Mismatch Between Social Media Users and the U.S. Population

Sean Callahan

Cal State Fullerton

Social media plays a role in sampling the opinions and responses of various demographics within society. However, studies have shown that the relation between the social media users and the general population has representative differences. The purpose of this research is to identify if there is a gender mismatch between Twitter users and the general population of the United States. To determine the gender of a user, we constructed a model consisting of several machine learning algorithms, specifically the Random Forest of Decision Trees Classifier, the K-Nearest Neighbor, and the Support Vector Machines methods. These algorithms were ran against frequency vectors from the parts of speech obtained from each individual user's profile description. These algorithms use training sets determined by the Social Security Administration records on gender. In our analysis, we compare these results to the gender distribution of the United States using chi-square tests. This determines whether the gender distribution among our sample of Twitter users is representative of the gender distribution of the United States. Our results indicate that it is possible to determine the gender of a user using the frequency of parts of speech from their Twitter profile description, and we conclude that there is a gender mismatch between Twitter users and the United States population.

Virginia A **4:00P.M. – 6:15P.M.**

4:00–4:15

Sums of Cubes in Quaternion Algebras

Blake Schildhauer

McDaniel College

Generalization of Waring's Problem – that for every natural number k there exists an integer $g(k)$ such that every natural number can be written as the sum of at most $g(k)$ k-th powers – have been studied in a variety of contexts from algebraic number fields to non-commutative groups. We will extend results on sums of cubes in the complex numbers to give bounds for $g(3)$ for certain quaternion algebras.

4:20–4:35

Full Elasticity of Local Singular Arithmetic Congruence Monoids

Jason Thoma, Efron Licht, Gabriel Arias, Cassandra Smith,
Rizwan Maknojia, Ryan Moore, and Tessa Young

San Diego State University

Arithmetic Congruence Monoids, or ACMs, are arithmetic sequences of nonnegative integers that maintain the structure of a monoid that develop from non-unique factorizations of numbers. That is to say, an ACM is a closed set of positive integers under multiplication that contains the number 1. More succinctly, given two nonnegative integers a and b, the ACM that is defined by these two integers is where and; the second restriction is sufficient to ensure that is closed. There are two classifications of ACMs: when an ACM is called Regular, otherwise an ACM is called Singular. A further classification of singular ACMs occurs when , for some prime p and then the ACM is called a local, singular ACM. Elasticity is a property of ACMs that looks at the ratio between maximal lengths of factorizations to minimal lengths of factorizations of a given element in the ACM. An ACM is said to be fully elastic if for every rational number q and , where is defined as the maximal elasticity of all elements of the ACM, there exists some element in the ACM whose elasticity is equal to q. This paper will look at the property of full elasticity in local, singular arithmetic congruence monoids.

4:40–4:55

The Structure of the Gaussian Integer Primitive Pythagorean Triples

Tomoko Tachibana

Utah State University

Recall that a *Gaussian integer* has the form $a + bi$ where a and b are integers and i is the root of $x^2 + 1$. A *primitive Pythagorean triple* (PPT) is a triple (a, b, c) such that $a^2 + b^2 = c^2$ and $\gcd(a, b, c) = 1$. A *Gaussian primitive Pythagorean triple* (GPPT) is a triple (A, B, C) of Gaussian integers that satisfy the constraints for a PPT and in addition the real parts of A, B, and C are nonnegative, $Re(A) < Re(B)$, and if $Re(A) = Re(B) = Re(C) = 0$ then $Im(A), Im(B), Im(C) > 0$.

In 1963 Barning showed that any PPT, regarded as a 3-dimensional vector, can be transformed into $(3, 4, 5)$ via a finite number of left multiplications by one of three unimodular matrices we call *generator matrices*. Call $(3, 4, 5)$ the *core* of the set of PPTs. Briefly, we pursue analogous results to those of Barning for the GPPTs. We show that there is not a single *core*, but, for any GPPT x, there exists a pair (C, C') such that (1) x is transformed into a GPPT C via a finite number of transformations by a generator matrix G, (2) C is transformed into C' also by G, and (3) C' is transformed into C in the case that x is not transformed into either $(3, 4, 5)$ or $(3i, 4i, 5i)$. Call (C, C') a *relative core-pair*. We develop results that show the set of GPPTs can be partitioned into equivalence classes based on their relative core pairs, and the relation $\sim$, where, for GPPTs x and y, $x \sim y$ if and only if there is a matrix G for which $Gx = y$.

5:00–5:15

Extremal Trinomials over Quadratic Finite Fields

Sean Owen

University of Maryland, Baltimore County

Finding the roots of polynomials over finite fields is a problem of considerable importance in number theory and cryptology. While much effort has gone into understanding the asymptotics of the number of roots over finite fields with $q = p^k$ elements as a function of q, gaps remain in our knowledge for certain cases with k equal to 1 or 2. In particular, while upper bounds have recently been found for the number of roots of univariate t-nomials over F_q, tight upper bounds are completely unknown for the case $k = 2$. We make some first steps toward attacking this question by examining trinomials over F_q of the form $1 + ux - (u + 1)\,x^d$, with $q = p^2$ for a prime number p, u in F_q^*, and d in $\{2...q - 2\}$. Firstly, we provide data on the maximal number of roots over F_q for certain small values of q, acquired through computational experiments. Aided by this data, we then formulate tighter upper bounds on the maximal number of roots. This helps us formulate a finite field analogue of Descartes' Rule, refining the recent work of Bi, Cheng, and Rojas.

5:20–5:35

Bound for the Number of Possible Roots of Sparse Polynomials Over Finite Prime Fields

Zander Kelley
Texas A&M

We are interested in estimating the maximal number of roots of sparse polynomials over the prime field F_p. Cheng, Gao, Rojas, and Wan (2015) established a lower bound for this maximal number: There are infinitely many primes p such that the trinomial $x^n - x - 1$ has at least $\Omega\left(\frac{\log\log p}{\log\log\log p}\right)$ roots in F_p (and as many as $\Omega\left(\frac{\log p}{\log\log p}\right)$ roots assuming the Generalized Riemann Hypothesis). The best current upper bound for the number of roots of trinomials in F_p (under mild assumptions to avoid vanishing on large cosets) is $O(\sqrt{p})$. However, initial computational data strongly suggests that this number may grow as slowly as $O(\log p)$. We investigate the causes of this behavior, using connections to the Chebotarev Density Theorem, continuous approximations of large finite fields, and probabilistic heuristics. In particular, we report on results from a new large-scale computation involving a super-computer.

5:40–5:55

Refining Fewnomial Theory for Certain 2×2 Systems

Mark Stahl
The University of Texas at Austin

Finding the correct extension of Descartes' Rule to multivariate polynomial systems remains a difficult open problem. We focus on pairs of polynomials where the first has 3 terms and the second has m, and we say these systems are of type $(3, m)$. For these systems, recent work has determined that the maximum finite number of roots in the positive quadrant lies between $2m - 1$ and $\frac{2}{3}m^3 + 5m$. The techniques applied so far are variants of Rolle's Theorem and a forgotten result of Polya on the Wronskian of certain analytic functions. We add to these techniques by considering curvature, as a step toward establishing sharper upper bounds. We also build new extremal examples of minimal height. This research was done at Texas A&M University as part of the 2015 Algorithmic Algebraic Geometry REU.

6:00–6:15

Combinatorial Quantum Modular Forms

Caleb Ki, Yen Nhi Truong Vu, and Bowen Yang
Amherst College

Quantum modular forms, defined by Zagier in 2010, have been studied by many authors including Bringmann, Folsom, Ono, Rhoades, Rolen and others within the last few years. In this talk, we will discuss combinatorial and analytic properties of quantum modular forms which are intimately related to strongly unimodal sequences of integers. In particular, we will investigate special values of these and related functions on boundary of the unit disk, which a priori contains numerous singularities.

Virginia B **4:00P.M. – 6:15P.M.**

4:00–4:15

Optimal Pentagonal Tilings

John Berry
Williams College

We study and catalog new perimeter-minimizing unit-area tilings of the plane by pentagons.

4:20–4:35

The Double Gaussian Isoperimetric Problem

Jason Liang
University of Chicago

In the Euclidean plane, a circle solves the isoperimetric problem: it provides the least-perimeter way to enclose a given area. In the plane with Gaussian weight or density, a straight line solves the isoperimetric problem: it provides the least-weighted-perimeter way to enclose a region with prescribed weighted area. (Because the density dies off exponentially, the line has finite weighted length and the half-plane on either side has finite weighted area.) We consider the isoperimetric problem where the density is the sum of two Gaussian densities.

4:40–4:55

Equal Circle Packing on Flat Klein Bottles

Robert Dickens and Samantha Moore
University Of Maryland – Baltimore County and University of Northern Colorado

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 onto a boundaryless container called a flat Klein bottle. Using numerous figures we will introduce all the basic concepts (including the notion of a flat Klein bottle, an optimal packing and the graph of a packing), illustrate some maximally dense arrangements, and outline the proof of their optimality. This research was conducted as part of the 2015 REU program at Grand Valley State University.

5:00–5:15

Relaxed Disk Packings

Yingyi Zeng
St. Mary's College of Maryland

The classic result about the optimal hexagonal packing of unit disks in the plane has recently been partially generalized by Edelsbrunner et al. to allow but penalize overlap. We extend these new results.

5:20–5:35

The Convex Body Isoperimetric Conjecture

Matthew Dannenberg
Harvey Mudd College

The Convex Body Isoperimetric Conjecture states that the least perimeter needed to enclose a given volume inside an open ball in $\mathbb{R}^n$ is greater than inside any other convex body of the same volume. The two-dimensional case has been proved by Esposito et al. for the case of exactly half the volume. We give some further partial results.

5:40–5:55

Unfolding a Polytope

Sean Suehr
Lake Superior State University

In 1525, the German painter, thinker, and geometer Albrecht Dürer conjectured that "every convex polytope has a non-overlapping edge unfolding". A non-overlapping edge unfolding is obtained by cutting along a chosen set of edges of the polytope. The resulting unfolded polytope is connected and lies flat on a plane without overlapping pieces. We call unfolded polytopes nets. As of yet, no algorithm exists to successfully determine the set of edges necessary for a flat, non-overlapping unfolding of any convex polytope. Another way to unfold a polytope is the star unfolding, which was shown by Aronov and O'Rourke in 1991 to always produce a non-overlapping net. We will perform a star unfolding during the presentation. To perform the star unfolding start by finding a point in general position on the surface of the polytope. A point in general position has unique shortest paths to all vertices along the surface of the polytope. We then cut the shortest paths from our point in general position along the surface of the polytope to each vertex. This always produces a flat, non-overlapping net. Understanding why the Star Unfolding produces a flat non-overlapping net may provide insight for finding an algorithm to prove Dürers conjecture.

6:00–6:15

Coarse Embeddings of Graphs into Hilbert Space

Michael Perlman and Dylan Bacon
University of Wisconsin - Stout

The notion of coarse embeddability of metric spaces into Hilbert space was introduced by Gromov with the study of the Novikov conjecture for discrete groups. One reason for the recent interest in coarse embeddings into Hilbert space is the result by Yu, which implies that a discrete metric space with bounded geometry that coarsely embeds into Hilbert space satisfies the coarse Baum-Connes conjecture. We will discuss the conditions under which a union of coarsely embeddable graphs is also embeddable.

Virginia C **4:00P.M. – 6:15P.M.**

4:00–4:15

Neural Codes Closed Under Certain Intersections

Zev Woodstock
James Madison University

How does the brain encode structure? One device is via neurons called *place cells*, which won neuroscientists the 2014 Nobel Prize in Medicine. Place cells encode spatial memory and always fire in specific clusters when an individual resides in a familiar space X. Each place cell corresponds to a convex open region $U_i \subset X$, i.e., the cell becomes active when the individual is located in U_i. We characterize which firing patterns, or "neural codes" can arise from place cell activity. These neural codes are called *convex*. It has been proven that if a neural code is closed under intersections, then it is convex. However, there exist convex codes not closed under intersection that are also convex. We characterize this larger class of neural firing patterns. This type of classification will allow neuroscientists to identify which neural firing patterns display spatial information.

4:20–4:35

An Infinite Family of Chemical Reaction Networks with Multiple Non-Degenerate Equilibria

Bryan Félix
University of Texas at Austin

We can consider a chemical reaction network as a directed graph between the reactants and the products; e.g. $A + 2B \to C$ (one molecule of A binds with two molecules of B to produce one molecule of C). As the reactions take place, the concentration of the reactants will change. To study such changes, we make use of *mass-action kinetics* to define a system of ordinary differential equations $f(x)$ that describes how the concentration vector x will change with respect to time.

We call x^* an equilibrium point if $f(x^*) = 0$. Furthermore, x^* is said to be *non-degenerate* if and only if det$(\partial f(x^*)) \neq 0$, where $\partial f(x^*)$ denotes the Jacobian matrix of the system f evaluated at x^*. The main object of this talk is the network $\widetilde{K}_{m,n}$ defined, for positive integers $n \geq 2$ and $m \geq 1$, as the network:

$$\begin{gathered} X_1 + X_2 \to 0 \\ \vdots \\ X_{n-1} + X_n \to 0 \\ X_1 \leftrightarrow 0 \\ \vdots \\ X_n \leftrightarrow 0 \\ X_1 \to mX_n \end{gathered}$$

Previous results show that the network $\widetilde{K}_{m,n}$ admits multiple equilibria if and only if n is odd. In this talk we further characterize values of n and m for which the system admits multiple *non-degenerate* equilibria.

4:40–4:55

Detecting Obstructions to Convexity in Neural Codes

Caitlin Lienkaemper

Harvey Mudd College

How does the brain make sense of space? The 2014 Nobel Prize was awarded to John OKeefe, May Britt Moser, and Evard I. Moser for the discovery of place cells, grid cells, and head direction cells, cells whose firing patterns encode a cognitive map. Given a set of neurons, the set of all observed firing patterns gives rise to a neural code. We are especially interested in convex neural codes, those which can be generated from the intersections of a collection of convex open sets in $\mathbb{R}^d$, because these codes arise from place cells. Previously, neural codes have only been classified as convex or not on up to four neurons. Since there are 2^{31} neural codes on five neurons, it is not feasible to classify codes on five or more neurons by hand. To narrow down the search space, we note that a convex neural code must have no local obstructions; it is not known if the converse of this statement is true. We refine criteria to determine when a neural code has local obstructions and develop an algorithm to generate all codes on five neurons without local obstructions, and use this towards classifying neural codes on five or more neurons.

5:00–5:15

Modeling Influenza B outbreak at Trinity

Subekshya Bidari

Trinity College

In the spring of this year, Trinity College experienced an outbreak of influenza B. Twelve students were infected in the month of May right before finals week. Fortunately, the school year ended shortly after the initial outbreak likely preventing a larger spread of the disease. Using SIR-type models and data from this outbreak, I model this outbreak to see what would have happened had the outbreak occurred during the middle the school year. I also incorporated varying level of vaccination and the effect of stochasticity in the outbreak.

5:20–5:35

Modeling Newt and Crayfish Population Dynamics in Santa Monica Mountain Streams with Flooding and Drought Conditions

Marjorie Jones

Pepperdine University

The native California newt (Taricha torosa) population, an amphibian in Santa Monica mountain streams in southern California, is declining due to invasive crayfish (Procambarus clarkii). Newts require streams for egg laying and reproduction. Crayfish lack adaptability to high velocity stream flow; thus, flooding events can temporarily reduce the crayfish population while a period of drought might increase crayfish persistence. We create a differential equation-based mathematical model that considers the predatory relationship between crayfish and newts in a variable rainfall environment. We use the system to make predictions about the likelihood and time to local extinction of newts given the presence of crayfish. We then investigate the resulting effects on the newt population of recent and theorized flood or drought events. We expanded our model to a compartmental model that describes the migration of crayfish between multiple breeding pools. This allows us to address how physical barriers limit crayfish migration between newt breeding pools and impact the persistence of newt populations during drought or flood events. We use the model to predict whether local extinction of newt populations can be prevented without further restorative measures or human intervention.

5:40–5:55

Modeling Newt and Crayfish Populations in Santa Monica Mountain Streams with Manual Crayfish Removal

William Milligan
Emory University

Invasive species are the second leading cause of biodiversity decline and a known contributor to global decline in amphibian populations. Twenty years of data demonstrate that Santa Monica Mountain streams have been colonized by invasive crayfish (Procambarus clarkii) that have severely reduced native newt (Taricha torosa) populations. Flooding events temporarily lower crayfish populations, which allows newts to reproduce that year. As the California drought continues, flooding events become less frequent, which increases the need for human intervention to promote newt persistence. However, manual crayfish removal can only occur intermittently. My research addresses to what extent crayfish trapping must occur to prevent extinction of newts in local streams, during high or low rainfall periods. We create predator-prey-type differential equation models to analyze the effects of persistent versus intermittent crayfish removal on newt survival in a single breeding pool. We then expand these models to multiple compartments to incorporate spatial differences due to multiple breeding pools in each stream. We parameterize the models with population data gathered from several local streams. We analyze the models and parameter sensitivity to determine the long term behavior and persistence of each newt population. The results are interpreted in a biological context to address possible restorative measures to prevent newt extinction.

6:00–6:15

Lyme Disease: A Mathematical Approach

Carlos Munoz
Texas A&M University

Lyme disease, caused by the bacteria Borrelia burgdorferi and transmitted by the tick vector Ixodes scapularis, is becoming an increasingly interesting disease to study. B. burgdorferi can be found in many places across North America, including Texas and northern Mexico. Studies done to identify the host species in this area have been inconclusive, though there is evidence that individuals of the species I. scapularis prefer to quest at one of two distinct heights. We used an SI model with criss-cross infection to describe the transmission of B. burgdorferi between three different species. Most importantly we will discuss how the introduction of an invading species will impact the level of infection of Lyme disease within a community

Wilson A **4:00P.M. – 6:15P.M.**

4:00–4:15

Using Social Networking Analysis in Higher Education

Prabhat Kumar, Natalie Hurd, and Paul Johnson
West Chester University

The speakers will discuss several Social Network Analysis (SNA) research projects of which they were a part at their university. The aim of these SNAs was determine ways to maximize interactions between faculty and the flow of information across the campus. Areas of particular interest included the use of High Impact Educational Practices and support systems for Underrepresented Minorities. This talk will highlight the research methods used to conduct the SNA and the major results of several SNAs.

4:20–4:35

$\mathbf{C^*}$-Algebra from $\mathbf{k}$-Graph and 2-Cocycles

Gereltuya Erdenejargal and Oliver Orejola
University of Colorado Boulder

A k-graph is a combinatorial object, given by an edge-colored directed graph and a set of equivalence classes of different paths between the vertices. By defining a special function, 2-cocycle, on a k-graph we can construct a C^*-algebra. The C^*-algebras are studied in functional analysis and have a primary application in quantum mechanics. We are interested in k-graphs and 2-cocycles, because they are simple to build and analyze, but complicated enough to provide a variety of examples of C^*-algebras. Our research studies the connections between the properties of the k-graphs and 2-cocycles and how they relate to the properties of different C^*-algebras. In our talk, we will introduce the colorful world of k-graphs, and also discuss the general connections between two equivalence relations for 2-cocycles-cohomology and homotopy, which have significant implications in the C^*-algebra level. You do not need a knowledge of C^*-algebras to understand this talk.

4:40–4:55

Degree Sequences of Partial Halin Graphs

Theresa Marlin
DeSales University

A Halin graph is a planar graph $T \cup C$, where T is a tree with at least 4 vertices and no vertices of degree 2, and C is a cycle through the leaves of T. In this talk, we discuss the characterization of the degree sequences of Halin graphs. We then explore the degree sequences of partial Halin graphs, which are spanning subgraphs of Halin graphs. We furthermore describe how our desire to characterize the degree sequences of partial Halin graphs originates from a related edge-coloring problem.

5:00–5:15

Quantum Walks, State Transfer, and Rooted Products

Ethan Ackelsberg

Bard College at Simon's Rock

Given an undirected graph $G = (V, E)$ with adjacency matrix A, a *continuous-time quantum walk* on G is given by the transition matrix $U(t) = e^{-itA}$. The quantum walk on G has *pretty good state transfer* between vertices $u, v \in V$ if the magnitude of the (u, v)-entry of $U(t)$ gets arbitrarily close to one (if it equals one, the state transfer is called perfect). This notion has been extensively studied in the context of information transfer in quantum spin networks. The behavior of quantum walks under various graph operations has been used to construct infinite families of graphs exhibiting state transfer. An operation that is not well understood in the context of quantum walks is the rooted product of graphs. The *rooted product* of G and a rooted graph H is the graph obtained by attaching to each vertex of G a pendant copy of H. This product was introduced by Godsil and McKay (1978), and a recent work by Makmal et al. (2014) provides numerical evidence for state transfer in rooted products with hypercubes. In this talk, we will show that certain classes of rooted products cannot have perfect state transfer. In addition, we will explore examples where there is pretty good state transfer.

5:20–5:35

Algebraic Invariants of Families of Graphs

Noah Watson

James Madison University

A major algebraic invariant of graphs is the critical group, which can be understood both algebraically and combinatorially. Given a graph Γ on n vertices, we can view its Laplacian as a map: $L : \mathbb{Z}^n \to \mathbb{Z}^n$. The critical group $K(\Gamma)$ is defined to be the torsion subgroup of $\mathbb{Z}^n/IM(L)$. Critical groups are known for only a few families of graphs. For example, cycle graphs and complete graphs have known critical groups, while others like the n-cube are not completely characterized. Combinatorially, we can think about playing a chip-firing game on our graph Γ. We begin by placing a non-negative number of chips on every vertex of our graph except for one that we will call the bank. The bank has the negation of the sum of the chips on the other vertices, so that the total sum of all vertices is zero. This set-up is called a configuration of the graph. If a vertex has more chips than its degree, it can "fire" by sending one chip to each adjacent vertex, with the bank firing only when no other vertices can. Two configurations are considered equivalent if one can be reached from the other through chip-firing. A configuration is called critical if no vertices but the bank can fire and we can get back to it through chip-firing. In this talk, we will look at the relationship between these two definitions and give the critical groups for certain families of graphs.

5:40–5:55

Environmental Impact of Optimizing Hamilton Circuits

Rachel Shore

Agnes Scott College

MedShare is a medical supply distribution company that aims to bridge the gap between surplus and scarcity by donating America's unused medical supplies to hospitals in developing countries. Procuring these unused medical supplies involves employing a truck driver to collect medical supplies from barrels placed at clinical institutions throughout the San Francisco Bay area, where the company is located. In this talk we describe the graph theory techniques that can be used to find the optimal routes for the truck driver. Furthermore, we explore the environmental impact of MedShare implementing these new routes.

6:00–6:15

Applying Mathematical Theories to Real World Problems

Kayleigh McCrary and Victoria Wood

Agnes Scott College

The real world presents various logistical challenges with many different objectives, and more often than not, these challenges have no one solution. A classic graph theory problem often framed as one traveling salesperson with different destinations (so they may sell their goods) who wants to find the route that will save them the most time and money. The simplest solution would be to find the route with the smallest overall distance. However, real world companies with similar objectives often face the issue of having more objectives than minimizing mileage. In rush hour traffic, is this shortest route also the fastest route? Similar questions start to make the classic Traveling Salesperson Problem (TSP) more and more complex, and so these problems typically have no optimal solution, but can be solved for an efficient solution. MedShare is an environmentally-conscious, Non-Profit Organization that reclaims surplus medical supplies to donate to developing countries with qualified, but undersupplied healthcare facilities. They obtain their donations on a weekly basis, visiting donor facilities all over Georgia during peak rush hour times with one truck. MedShares donation routing problem is not so different from the classic TSP. Using data supplied by MedShare, we applied basic graph theory and data clustering algorithms to help make their routes more efficient.

Virginia A **8:30A.M. – 11:45A.M.**

8:30–8:45

Testing Gender Demographic Differences Between Politically Active Twitter Users and the U.S. Voting Population

Derrick Gutierrez
California State University Fullerton

Obtaining information about an entire population is often a difficult and infeasible task, particularly if the population size is large. Researchers often use a subset of the population, a proxy population, to make inferences about the entire population given the information from the sample. Social media websites have allowed researchers to obtain large datasets of information on a subset of the human population; however, this subset may not be a representative sample. In this case there is a proxy population mismatch, where there is a misrepresentation between the sample population and the whole population. This study focuses on the gender and location demographics between politically active U.S. Twitter users and the U.S. voters in order to determine whether Twitter is an appropriate representation of the politically active U.S. population. The dataset used for this study consists of tweets from New Year's Eve; since there were no political events surrounding New Year's Eve, the tweets are more likely to not be dependent on political events. From this dataset, we identify politically affiliated tweets through overtly used political terms and names of political figures. We then compare the location and demographics of these politically active Twitter users to the U.S. voting census data through statistical tests to assess whether there is a proxy population mismatch. Furthermore, we apply Natural Language Processing tools to categorize tweets as informative or opinionated. This study finds that Twitter is not an accurate representation of the U.S. voting population.

8:50–9:05

Language Usage of Social Media Sites and Their Representativeness as Proxy Populations

Hye Rin Lindsay Lee, Kaitlyn Cunanan, John Verdoza, and Matthew Wagerer
California State University, Fullerton

Twitter is a popular social media site that allows its users to share short 140 character messages with each other. These tweets are readily accessible and a great source of data to analyze. It is reported that approximately 382 different languages are in use within the United States borders. Although English is the most common language, we will focus on the use of non-English languages on Twitter. The goal of this study is to identify the primary language of a Twitter user and to detect multilingual Twitter users. In order to achieve this, we use the user's self-reported language, the language that Twitter detects in a tweet, and a Python language identification package called langid.py. With statistical testing, we use our results to determine that there is a mismatch between the Twitter proxy population and the general U.S. population as a whole.

9:10–9:25

Detecting Non-randomness: A Suite of Statistical Tests to Detect Fake Coin Flips and Identify Patterns in Real-world Data

Jiarui Xu

University of Illinois at Urbana-Champaign

Can one distinguish a head/tail sequence obtained by flipping a coin from a similar “made up” sequence of heads and tails, or a win/loss sequence of a basketball team from the scoring sequence in a basketball game? To the naked eye, such sequences all appear similarly “random”, and seem indistinguishable from one another. Yet, statistical tests can reveal unique features that make it possible to correctly classify the sequence, with a high level of confidence. In this talk we present preliminary results of an undergraduate research project at the University of Illinois aimed at answering questions of this type. We describe a suite of statistical tests we have developed for this purpose, and an interactive online “fake coin toss detector” that is based on these tests. We also report on the results of these tests when applied to a variety of real-world sequences from sports, finance, and everyday life. This is joint work with Xusheng Zhang.

9:30–9:45

Logistic Regression Analysis on the Effects of College Algebra on College Students

Emily Hubbard

Arkansas State University

There are many variables that may affect students while they are taking their College Algebra course, we would like to analyze their relationship, so that the Department of Mathematics and Statistics can use the information to enhance our College Algebra courses. I also plan to present the results to the Arkansas department of Education, so that this may help them to enhance the College Algebra courses across the state. First, multivariate random sampling technique is used to choose a random sample from universities in Arkansas, followed by online/paper surveys. Then, the relationship between explanatory variables and students academic performance will be analyzed using logistic regression. The idea of logistic regression will be introduced, then the outline of our research will be presented, as an ongoing research.

9:50–10:05

Optimal Assignments of Control and Noise Factors for Robust Parameter Designs from Hadamard Matrices

Belina Santos and Debra Ingram

Arkansas State University

Robust parameter design (RPD) is a statistical experimental strategy for quality improvement. RPD allows engineers to optimize the settings in a manufacturing process so the effects of uncontrollable variables, called noise variables, are minimized. Robust parameter designs provide investigators with experimental plans for finding the settings of the control variables that dampen the effects of the noise variables, making the process robust to uncontrollable changes in nuisance factors. Robust parameter designs are taken from Hadamard matrices. These matrices have excellent qualities for minimizing aliasing between important effects such as control-by-noise interactions. This project focuses on extending the work of Loeppky, Bingham and Sitter (2006), Carraway (2008), and Cox (2011) to construct non-regular robust parameter designs.

10:10–10:25

Interactive Computation and Visualization of Probability Distributions

Steven Tipton
New York City College of Technology, CUNY

This project is based on recent developments in programming interactive web applications using the statistical programming language R and its IDE RStudio. The main goal of the project is creating an interactive Shiny app that computes and visualizes key statistics of various probability distributions, and displays key mathematical results, typeset in LaTeX, regarding the chosen probability distribution. This interactive web-based application could serve as an interactive probability calculator as well as a compact mathematical reference for the most common probability distributions encountered at the undergraduate level in the STEM fields. The list of available distributions includes some more exotic distributions such as the Lognormal and Pareto distributions, which are widely used in financial and actuarial science. One of the main objectives of this project is to create a multi-functional, interactive probability app that comes with a mathematical reference section, designed in a way that could feasibly replace the outdated paper-based probability tables and reference sheets used by any department that offers probability and statistics classes at any level.

10:30–10:45

Jimmy Fallon: #AlgorithmicTweeting for 15 Minutes of Fame

Natalie Wolford and Megan Searles
Brigham Young University

Everyone wants their 15 minutes of fame. Viral media consists of a vast amount of information exchanged over a short period of time. The Tonight Show starring Jimmy Fallon features a “hashtag game where humorous tweets must be selected from a viral hashtag within 24 hours. Out of the hundreds of thousands of tweets he receives, how does Jimmy Fallon choose the handful that he reads on the show? Using techniques from data analytics we determine what algorithm, if any, he uses to choose the tweets he reads. To do this we used web scraping, Naive Bayes, Python programming, and network theory.

10:50–11:05

Jimmy Fallon: #MathvsTheTonightShow

Derek Miller and Ashley Blair
Brigham Young University

In a previous talk, we used mathematics and data analytics to replicate how Jimmy Fallon selects tweets to be read on The Tonight Show. Is this the most efficient process for choosing tweets or can it be improved? With natural language processing, we answer this question and reveal an algorithm that is an optimal solution to the hashtag game problem.

11:10–11:25

Classifying Images using Stochastic Neighbor Embedding and Mapper

Jiyi Jiang

Hope College

We examine high-dimensional image data of handwritten digits. We will use variations of Stochastic Neighbor Embedding (SNE) to define a function that reduces the dimension of the data. Then, we will visualize the topology of the high-dimensional data using the Mapper algorithm, which examines clusters in the level sets the SNE function.

11:30–11:45

Analyzing Judging Calibration Practices

Austin States and Patrick Lenahan

Virginia Military Institute

We analyzed the SIAM/M3 triage judging practices using statistical methods, identified potential areas for improvement, and proposed further analysis including possible modifications to the scoring system.

Virginia B **8:30A.M. – 11:45A.M.**

8:30–8:45

Connecting Art and Math through Geometry and GeoGebra

Stina Nyhus
Utah Valley University

Many authors (T. Hull, D.P. Scher, S. Smith, etc.) have researched origami folding in connection with the conic sections, as well as the use of dynamic software to demonstrate those folds. In this presentation, it will be shown how these ideas can be extended to produce math-art designs with the help of the free GeoGebra software. Work done by V. Vasilevska has explored GeoGebra animations of segments of tangent to parabolas in creating math-arts designs. This work expands on those methods by animating segments of tangent lines to ellipses and hyperbolas. Several tools were created that use a constraining polygon/curve to create a best-fit shape inside them by using an animation of the produced tangent segments, resulting in beautiful works of geometric art featuring the conic sections. This talk will explore the tools created, the geometry behind their construction, and possible applications.

8:50–9:05

Quasi-Polynomials as Integer Point Counting Functions

Daniel Gulbrandsen
Utah Valley University

Let nP denote the polytope obtained by expanding the convex integral polytope $P \subset \mathbb{R}^d$ by a factor of n in each dimension. Ehrhart proved that the number of lattice (integer) points contained in nP is a rational polynomial of degree d in n. *What happens if the polytope is scaled by not necessarily the same factor in each dimension?* This question will be answered completely for dimension 2 for a particular scaling. In addition, a partial answer for dimension 3 will be provided. It will be shown that the number of lattice points contained in polytopes obtained by expanding P by this particular scaling is a quasi-polynomial in n. Quasi-polynomials are a generalization of polynomials, whose coefficients are periodic functions with integral period. Furthermore, particular cases of scaled polytopes where the number of such lattice points are just polynomials will be presented. At the end, future work will be discussed. Joint work with Christopher Vander Wilt.

9:10–9:25

On Cones of Pseudoeffective Divisors

Elijah Gunther and Olivia Zhang
Yale University

We study the invariant of algebraic varieties called the cone of pseudoeffective divisors. We present explicit descriptions of this invariant for a family of algebraic varieties constructed from projective space by performing a sequence of blowups along linear subspaces. We present applications of our descriptions, examples and an explanation of the main techniques used in our work.

9:30–9:45

Manipulation of DT codes

Kareem Hamdan
University of Texas at Dallas

In this work, we do an analysis of Dowker's codes of an alternating knot. Then we construct a bijective function which generates a set that can be partitioned into two classes, that is, a class of classical knots and a class of virtual knots, up to mirror images.

9:50–10:05

Transition between Classical Rational Tangles and Virtual Rational Tangles

Alexandra Fuchs
University of Texas at Dallas/ Summer NREUP at UNTD

We study the virtual generalization of classical knots in relation to connected sums and graph theory. The focus is on invariants of classical prime knots to verify the generalized properties for virtual prime knots. The main purpose of this work is to explore the transition, and to gain a better understanding of the connection, between classical and virtual knots.

10:10–10:25

Optimization of Maximal Contraction Ratio and Hausdorff Dimensions of Outer Sierpinski Fractals

Eduardo Padilla
University of North Texas at Dallas

We discuss an optimization problem regarding the contraction ratio and the Hausdorff dimension of the outward Sierpinksi's fractals of regular N-gons. By using some known results on inward Sierpinksi's fractals and infinite geometric series, we will derive the general formulae for the maximal contraction ratio and the maximal Hausdorff dimension. We will generalize the maximal contraction ratio and the maximal Hausdorff formulae for a certain regular N-gon that is not affected by in-growth.

10:30–10:45

Hausdorff Dimension of Generalized Fibonacci Word Fractals

Tyler Hoffman
McDaniel College

The Fibonacci word fractals are a class of fractals that have been studied recently, though the word they are generated from is more widely studied in combinatorics. The Fibonacci word can be used to draw a curve which possesses self-similarities determined by the recursive structure of the word. The Hausdorff dimension of the scaling limit of the finite Fibonacci word curves is computed and these computations are generalized to a larger family of fractals.

10:50–11:05

Folded States of Single-Vertex Origami

Jason Orozco

San Jose State University

Our presentation will consist of computer animations that vizualize the results of our research in single-vertex origami done as a class project at San Jose State University. Namely, we present a combinatorial definition of folded states for flat-foldable single-vertex origami with prescribed creases. Then, on the (uncountable) set of flat-foldable single-verticies having any fixed number of creases, we define an equivalence relation that yields a finite partition where the set of possible folded states for a given single-vertex origami is an invariant of its equivalence class.

11:10–11:25

Origami Mathematical Applications and Rigid Reachability

Robert Porter, Tyler Hills, and Austin Unsicker

Brigham Young University

One application of origami is the design of deployable, foldable solar arrays. We present a mathematical approach to solving the problem that many engineers consistently encounter when designing folding structures; that is, determining whether a folding pattern is rigid reachable. A rigid reachable design guarantees that a solar array will fold and deploy without causing damage to its solar panels. We have developed an algorithm to mathematically model folding patterns with one degree of freedom and prove whether they allow a rigid folding.

11:30–11:45

Techniques for Solving Generalized Elastica Problems

Alex Safsten

Brigham Young University

Elastica curves are the shapes made elastic materials when bent. Euler and others derived a differential equation solved by a special class elastica curves. I present a differential equation solved by a more general elastica curve. I show how this differential equation can be solved in some cases, and demonstrate an algorithm which solves it to numerical precision in others. Finally, I show how, given an arbitrary curve γ, one may construct an elastic mechanism whose elastica solution is γ.

Virginia C **8:30A.M. – 11:45A.M.**

8:30–8:45

A Combinatorial Interpretation of the LDU Decomposition of Totally Positive Matrices

Muhammad El Gebali
The American University in Cairo

In this talk, we give a description of the lower triangular L, the diagonal D, and the upper triangular U matrices of the LDU decomposition of totally positive matrices in terms of the combinatorial structure of essential planar networks described by Zelvinsky and Fomin. Similarly, we find a combinatorial description of the inverses of these matrices. In addition, we provide recursive formulae for computing the L, D, and U matrices of a totally positive matrix.

8:50–9:05

On Some Properties of Generalized Tribonacci-type Polynomials

Huei Sears, Alexander J. Durbin, and Alperin Sirin
Michigan State University and University of Rochester

Let $T_0(x) = \alpha(x), T_1(x) = \beta(x), T_2(x) = \gamma(x)$ and define

$$T_n(x) = f(x) \cdot T_{n-1}(x) + g(x) \cdot T_{n-2}(x) + h(x) \cdot T_{n-3}(x),$$

where $\alpha(x),\ \beta(x),\ \gamma(x),\ f(x),\ g(x)$, $h(x)$ are some functions of x. In this talk, we consider two special cases:

- Fibonacci-type polynomials of the form $\alpha(x) = 0$, $\beta(x) = -1$, $\gamma(x) = x - 1$, $f(x) = x^k$, $g(x) = x^l$, and $h(x) = 0$, where l and k are positive integers,
- Tribonacci-type polynomials of the form $\alpha(x) = a$, $\beta(x) = b$, $\gamma(x) = c$, where a, b, c are integers, and $f(x),\ g(x),\ h(x)$ arbitrary.

Analytic properties such as determinantal identities, closed form representations involving combinatorial terms, bounds for all the roots, and asymptotic results, specifically for the maximum real roots of the sequence of these polynomials will be presented.

9:10–9:25

On Proofs of Certain Combinatorial Identities

Marcus Elia and Ryan Bianconi
Geneseo State University of New York and Ithaca College

The problem of finding combinatorial proofs for new and old mathematical identities is among attractive mathematical problems. In this talk we present combinatorial and computerized proofs of interesting and challenging combinatorial identities. This research was conducted as part of the 2015 REU program at Grand Valley State University.

9:30–9:45

Counting Insertions in Permutations

Travis Spillum
Saint John's University

A permutation $a_1a_2\cdots a_n$ of $1, 2, \cdots, n$ is said to have an insertion at position r if there exists l,$m < r$ such that $a_l < a_r < a_m$. For any n we investigate the number of permutations with exactly k insertions.

9:50–10:05

Mastermind: Query Complexity of Finding Hidden Vectors

Christopher Chute, Aaron Berger, and Matthew Stone
Yale University

In this paper we will study a generalization of the popular board game "Mastermind." The game consists of two players: the codemaker and the codebreaker. At the start the codemaker chooses a vector $(x_1, x_2, \ldots, x_n)$ with $x_i \in [1, k]$, which is unknown to the codebreaker, and in each turn the codebreaker makes inquiries with the end goal to discover said vector. We will discuss asymptotics for the minimum number of of moves needed by the codebreaker to guarantee a success. We shall also explore variants of the problem such as algorithms for discovering a hidden matching in a bipartite graph.

10:10–10:25

Counting n-arcs in the Finite Projective Plane

Luke Peilen and Rachel Lawrence
Yale University

An n-arc in the projective plane over a finite field is a collection of n distinct points in the plane, no three of which lie on the same line. Our goal is to investigate formulae for counting these arcs. Such formulae are known through $n = 8$, but for larger n there remain numerous interesting open questions. These questions are related to special configurations of points that arise in number theory and algebraic geometry. In this talk, we seek a formula for counting 9-arcs and investigate problems about n-arcs for larger n.

10:30–10:45

Analysis of Sudoku Variations Using Combinatorial Techniques

Emily Alfs and Susanna Lange

Doane College and Grand Valley State University

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 puzzle have different rules, where the player is given other information or restrictions in addition to numerical clues. We present the results of our research of Sudoku variations, using combinatorial counting techniques. This research was conducted as part of the 2015 REU program at Grand Valley State University.

10:50–11:05

Developing an Educational Sudoku Application

Emily Hoopes and Jonathan Boyd

Youngstown State University and Kent State University

During the past year, we developed a Sudoku solving application that employs logical solving techniques to find the solution to a given Sudoku puzzle and then offer hints to the user to enable her to successfully complete the puzzle. Other Sudoku solver applications determine the correctness of a puzzle and determine the location of particular numbers, but do not advise the user which solving technique to use. Through logic, this application generates and solves puzzles while helping a user improve their Sudoku solving skills.

11:10–11:25

Tides of Vengeance: Balance and Probabilities in Game Design

Kristyn Roller and Zachery Cole

Asbury University and Cedarville University

A board game designer has many decisions to make for which mathematics can be an important tool. We consider the mathematics involved in designing a new game, Tides of Vengeance. A certain balance is desired between whether luck or skill determines the games outcome and probabilities can be computed to help find the right balance. Relative power between game characters is another factor to be considered. Finally, we consider geometric concepts in the visual layout of game boards. In all cases, the mathematics is used to help the designer make the game an enjoyable experience for the players.

11:30–11:45

Linear Diophantine Equations Versus the Penny

Laura Robusto and Tyler Searcy

Virginia Wesleyan College

Have you ever wondered how many ways there are to make a dollar? Sure, you can use 4 quarters, or 10 dimes, or 100 pennies. But using any combination of coins, how many ways are possible? Are there any combinations that use exactly 17 coins, or 98 coins? In this presentation we investigate the number of ways of combining n coins in our monetary system to make one dollar for each $1 < n < 100$ and discuss the necessity and efficiency of the coins in our monetary system. Using linear Diophantine equations, original methods, and previously known algorithms for change-making problems, we will build a case for abolishing the penny.

Wilson A **8:30A.M. – 11:45A.M.**

8:30–8:45

Collaborative Learning Models

Leah Granger
Clarkson University

Group-based learning provides an alternative learning environment to traditional lecture-based instruction. Previous studies have shown statistically signicant improvements in academic achievement as well as positive effects in attitudes towards learning and retention in STEM programs. To better understand how to maximize the benefits of group learning, we investigate the impact of group composition on individual achievement and the ways in which a given set of individuals should be grouped to increase effectiveness. We also consider the question of whether groups should be dynamic, with members switching over time. Using mathematical models created in Microsoft Excel and MATLAB, we simulate learning curves for theoretical individuals described by parameters representing their knowledge levels and abilities to learn. We analyze the effectiveness of a groups composition based on performance relative to other compositions.

8:50–9:05

Examining Disproved Mathematical Ideas through the Lens of Philosophy

Briana Yankie
Lee University

It seems that as long as mathematics and humanity co-mingle, ideas will be continually disproved before being improved in the world of mathematics. This can been seen through the examples of the Pythagorean's theory of commensurability, Euclid's Fifth Postulate, Fermat's assertion on prime numbers, and ancient ideas concerning the infinite. These mathematical ideas have significantly impacted mathematical philosophy, giving evidence for a philosophy that accounts for both the subject's perfection and the fallible beings that have shaped it. This presentation, also recently awarded as a first place paper in the HOM SIGMAA competition, promotes that together the philosophies of Platonism and socio-historic constructivism seem to best interpret this developing mathematical story.

9:10–9:25

A Class of Consequences of Cauchy-Schwarz Inequality

Melissa Riddle
California State University, Fullerton

The theory of analytic inequalities in advanced mathematics is of crucial importance. It's known that the triangle inequality in the n-dimensional Euclidean space reduces to Cauchy-Schwarz inequality. The idea to present elements of the more advanced theory of inequalities to Math Circle students is not new, since inequalities have been asked for several decades in various mathematical competitions all around the world. While working for the Fullerton Mathematical Circle, I reflected on the question: which inequalities are important? I will present a way of generating new inequalities based on a common pattern, and show how they are all related to the triangle inequality. We also illustrate how our Fullerton Mathematical Circle high-school students respond to such techniques.

9:30–9:45

Simulating the 19th Century Integraph Device

Kan Xue

Borough of Manhattan Community College (BMCC) CUNY

The goal of this paper is to present the simulated Integraph device and show several animations of what it does. The original Integraph device was a mechanical instrument used in late 19th and early 20th centuries for plotting the integral curve of a graphically defined function as the differential curve. We will present animations for several differential curves, showing how particular integral curves are being traced by the simulated Integraph for each given differential curve. The underlying mathematics of the simulated Integraph that we have implemented, using the programming language R, is the same as the mathematics behind the mechanical device that was constructed by Coradi of Zurich, based on the design by the Polish-Lithuanian mathematician and electrical engineer Bruno Abdank-Abakanowicz.

9:50–10:05

A Topological Approach to the Existence of Solutions of Calculus of Variations Problems

Logan Tatham

Brigham Young University

Calculus of variations is a powerful tool used to optimize a mapping from function space to the real numbers, called a functional. Much work has been done on the existence of extremum based on convex analysis and the convexity of the functional. In this presentation, we present a new theorem which guarantees the existence of extrema based on topology of the function space rather than the convexity of the functional.

10:10–10:25

Computer Generated Dynamic Systems of Outer Billiards

Abdullah Khan

University of Texas at Dallas

We discuss the dynamics of dual (outer) billiard system with finitely many singularities. First, we focus our attention to regular polygons, and study the singularity structure created by the dual billiards's path around the polygon. And then, we will expand our scope further toward irregular polygons and curvilinear shapes. We use Java programming and C programming to map our figures and analyze our visualization.

10:30–10:45

Exact Real Computer Arithmetic Using Continued Fractions

Richard B. Elrod

Youngstown State University

This presentation examines the use of continued fraction expansions in exact real computer arithmetic [Exact real computer arithmetic with continued fractions; J. Vuillemin]. The goal is to eliminate rounding errors found in traditional floating point arithmetic, preserving complete accuracy at each step until the final calculation, at which point user-selected truncation error may occur. As appropriate, the role of topological properties of $\mathbb{R}$ will be examined as they relate to continued fraction expansions.

10:50–11:05

An Investigation of Lambda-Permutations

Joseph Gaber and Joshua Postel

University of Michigan-Dearborn

Riemann showed that any conditionally convergent series can be rearranged by a permutation to diverge or sum to any real number. A λ-permutation is defined by Krantz and McNeal as a permutation which preserves the convergence of any convergent series, and causes at least one divergent series to converge. Velleman introduced the notion of *blocks* of a permutation and we expand upon this idea by defining *gaps* of a permutation and describing how they relate to λ-permutations. Using new terminology we categorize some series that can be made to converge via a λ-permutation. For such a rearrangeable series, we investigate an open question posed by Velleman, namely we determine the range of values which a divergent series can be made to converge to using λ-permutations.

11:10–11:25

A Construction of the Hyperreals using Ultrapowers

Carl Dean

Duquesne University

When Leibniz invented calculus, he used the idea of an infinitesimal number, a positive number that was smaller than any positive real number, to prove results like the product rule or the quotient rule. This idea of an infinitesimal as given by Leibniz seems problematic, though, as these types of numbers dont exist in the field of real numbers! Leibnizs intuitive treatment of calculus was eventually replaced with the ‘epsilon-delta treatment of calculus that one encounters in an upper level analysis course. It wasnt until the 1960s, though, when a mathematician named Abraham Robinson rigorously developed non-standard analysis, a form of calculus that rigorously used the ideas of infinitesimals. In this talk, we will discuss the construction of the hyperreals, a particular extension of the reals which allows nonstandard analysis to be developed. This will be done by taking ultrapowers of an ultrafilter of the natural numbers. All necessary concepts will be defined in the talk. Time permitting, we will discuss the importance of being able to rigorously found nonstandard analysis.

11:30–11:45

Reflections on Group Theory

Armin Niakan and Arash Barmas

Moorpark College and Pierce College

We try to present a very short history of group theory. We will also talk about its fundamentals, how and why it came to existence and where it is today.

MAA Session #19

Virginia A **2:00P.M. – 3:55P.M.**

2:00–2:15

On Burgers Equation on Time-space Scale

Anita Mizer

Kent State University

In 1968 Lax introduced the linear operator equation that is equivalent to the nonlinear Korteweg de Vries equation that described traveling water waves.¡br /¿In 1988 Hilger introduced the time scale calculus that unifies continuous and discrete analysis. We derive the Lax equation on a time-space scale. From this equation using the Ablowitz, Kaup, Newel, Segur and Ladik method the integrable nonlinear Burgers equation on a time-space scale is obtained. Similar to the continuous case this equation could be transformed to the linear heat equation on a time-space scale by Cole-Hopf transformation.

2:20–2:35

Introspection Into Two-Dimensional Dirichlet Problems

Brandon Allen

Winona State University

The Laplace Equation,

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = 0$$

is applicable in many fields of Applied Physics, such as Thermodynamics (heat plates), Hydrodynamics and Electrostatics. The Dirichlet problem is interesting in the fact that the value of the steady-state temperature is prescribed at each point along the boundary of a plate. The Dirichlet problem concerning the annulus makes it so that the Laplace Equation is satisfied in the domain and that $g(x, y) = \phi(x, y)$ for all points on the boundary. The Dirichlet problem also focuses on solving the temperature of the domain, $\phi(x, y)$ and the heat flux of the domain $\psi(x, y)$ to form into the complex potential function:

$$\Omega(z) = \phi(x, y) + i\psi(x, y)$$

However, sometimes we are concerned with infinite boundary curves. Finding out how an infinite domain works is hard to do because humans cannot even comprehend the infinite. In this presentation, through the help of Mathematics and Philosophy we will understand the infinite dynamic that the Dirichlet problem of the Annulus and disc presented in an alternative way.

2:40–2:55

Vanishing Viscosity Limits for the Lagrangian Averaged Navier-Stokes Equation

Bethany Barber, Ellen Prochaska, and Sruti Prathivadhi

Creighton University

The Lagrangian Averaged Euler and Lagrangian Averaged Navier-Stokes equations are recently derived approximations to the Euler and Navier-Stokes equations, respectively. As the name suggests, the Lagrangian Averaged Navier-Stokes are derived by averaging at the Lagrangian level, and the resulting PDE's have more easily controlled long time behavior at the cost of a more complicated nonlinear term. In this project we consider the vanishing viscosity problem for circularly symmetric flows.

3:00–3:15

The Extended States Conjecture in a Complex Plasma Crystal

Kyle Busse, Constanze Liaw, and Lorin Matthews
Baylor University

Although the Anderson localization conjecture (that random disorder of any strength causes electron localization within an ordered medium) has been proven mathematically for strong disorder in all dimensions, the problem of rigorously proving it for small disorder in dimension 2 (the “critical dimension) remains an open question. The absence of localization implies the existence of extended states. A mathematical approach recently developed by Liaw to confirm the existence of extended state is applied to a numerical model of a two-dimensional dusty plasma crystal, representing a physical system which can be experimentally realized. We hereby challenge the Anderson localization conjecture for small disorder.

3:20–3:35

Exploration of a Quantum Mechanical Particle in a Toroid

Justina R. Yang
Yang Academy

We consider a quantum mechanical particle trapped inside a toroidal potential well—the potential of the particle is zero inside a certain toroid and infinite elsewhere. Taking the particle’s total energy to be constant, we analyze its behavior by solving the time-independent Schrödinger equation for its wave function and by determining its valid energy levels. Our model uses a rectangular toroid, the solid of revolution generated by rotating a rectangle about an external axis parallel to one of its edges. We then compare the results of this model to available experimental data on the electronic energy levels of benzene.

3:40–3:55

GPS Positioning Algorithm, its Errors and Solutions

Mohammed Abdi and Hohite A. Fetene

Benedict College

The Global Positioning System is a space-centered satellite which consists of 24 basic satellites carrying atomic clocks navigation system that are responsible for delivering location and time information prudently, anywhere on Earth. If three satellites are available, then three spheres are known whose intersection consists of two points. One is the location of the receiver and the other is far away from the surface of the earth which can be ignored. As a result, the problem is to solve the three sphere equations. One major problem is that the receiver clock is not perfectly in sync with the satellite clock. The only way to fix this error is by adding one more. We define d to be the difference between the coordinated time on the (four) satellite clocks and the earth-constrained receiver clock. Two further problems arise when GPS is deployed. One is the conditioning of the system of equations and another is the transmission speed of the signals, which is not precisely the speed of light (c). Because the signals may encounter blockage by different hindrances on earth before reaching the receiver, this is referred to as multipath interference. To be more accurate, we increased the number of satellites from four to eight in our calculation. Our goal was to solve the least squares system of eight equations in four unknown variables (x, y, z, d) using Gauss-Newton iteration method. We used two types of satellites such as tightly and loosely bunched. Results indicated that system becomes ill-conditioned when satellites are bunched closely in the sky. Future research involves working with two or more receivers to compute difference of position instead of absolute position. Errors that are shared by the receivers will be canceled when we form the differences.

2:00–2:15

No Talk

Speaker Canceled

NA

2:20–2:35

Bats, Ecology and Public Health

Julia Martin

SUNY Oswego

In 2000 the Bats in the Bedroom policy changed to having all bats caught in the home while someone was in the room were to be taken and tested for rabies. What is the probability that a bat caught and tested had rabies and what is the transmission rate from bat-to-human related to these results? And has this policy change been effective? In 2006/2007 the bat population began to struggle with white nose syndrome in New York State. By 2009 this disease decreased the bat population by 90% from the 2006 estimates. How has this decrease in population affected rabies testing and results?

2:40–2:55

Predictive Measures of HIV Clearance

Eric Jones

Colorado School of Mines

Most HIV models are only applicable for the first acute stage of infection. In contrast, common predictive measures that are used to determine if HIV will be cleared from a host, such as the basic reproductive number, are valid only in the limit as time tends to infinity. An alternative and novel ”finite time horizon” method defines viral clearance based on the virion count at the model's final time of validity. Given different probability distributions of parameter values that are based upon clinically-acquired data, the predictions of the infinite and finite time clearance criteria are compared, and it is found that the finite time predictive measure fits clinical data more closely than prediction based upon the basic reproductive number.

3:00–3:15

Ebola Virus and SEIR Model

Paul Diaz and Chelsea Sandridge
Colorado School of Mines

Ebola virus disease is a dangerous infectious pathogen that poses a clear and present danger to the human population. The most recent outbreak of Ebola has taken root in Western Africa and has brought destruction to the countries of Guinea, Liberia, and Sierra Leone. The international community has provided some relief response to the epidemic, but this has not yet been enough to halt the epidemic. Our primary goal was to determine the optimal location to place a hospital in Western Africa. To gain insight into the spread of the disease, we developed a modified SEIR model and fit parameters to data pertaining to the current epidemic. After running our simulations, we developed different metrics to determine the best location to place a hospital. Through our analysis, we established that the country of Liberia was most susceptible to changes in the rate of infectious individuals entering hospitals. This indicated a marginal benefit in adding a hospital to Liberia when compared to Sierra Leone, and a significant benefit compared to Guinea when measuring total change in cumulative infection numbers.

3:20–3:35

On Perfect Secure Domination in Graphs

Peter Gartland
The Catholic University of America

A dominating subset S of a graph $G = (V, E)$ is called a secure dominating set of G if for each u in $V - S$, there exists a v in S such that v is adjacent to u and v replaced by u in S is still dominating in G (we say u is S-defended by v). It may happen that vertex u in $V - S$ may be S-defended by more than one vertex in S. This motivates us introduce perfect secure dominating set and perfect secure domination number of a graph. A secure dominating set S of a graph G is called perfect secure dominating set if for each u in $V - S$ there is exactly one v in S such that v S-defends u. Perfect secure domination number of G is defined as the minimum cardinality of a perfect secure dominating set of G. We initiate a study of this parameter and determine perfect secure domination number of some standard graphs. We conclude by showing that for any two integers a and b, with a less than or equal to b, we can construct a graph G where secure domination number of G is "a and perfect secure domination number of G is "b". This is joint work with S.V. Divya Rashmi (Srinivas Institute of Tech), S. Arumugam (NCARD,Kalasalingam University), and Kiran R. Bhutani (Catholic University of America).

Virginia C **2:00P.M. – 3:55P.M.**

2:00–2:15

Optimizing Strategic Decisions in "Settlers of Catan" using Linear Programming

Kyle Steele
University of Central Oklahoma

The board game "Settlers of Catan" is much loved around the world. As a game, it revolves around using scarce resources to build and develop a player's civilization. This feature lends itself to the application of linear programming. We develop a model for the basic structure of the game and show how it can be used to optimize key strategic decisions during gameplay.

2:20–2:35

On the Numerical Solution of the Black-Scholes Option Pricing Model

Hriday Bharat Thakkar and Narayan Thapa
Minot State University

In a rapidly changing financial market, various methods and tools to minimize financial risk are of great interest to individuals and businesses. Investors often use derivative instruments, such as options as tools to minimize risk but rapidly changing markets have made such instruments extremely complex. Thus, mathematical models that are both approachable and applicable are essential to implement and price derivative instruments. In this particular interdisciplinary approach, we focus on one such ground-breaking mathematical result in financial theory, the so-called Black-Scholes model, which is a widely used tool for estimating the price of an option. This work deals with the construction of a finite difference scheme and the numerical analysis of its solutions for the Black-Scholes model.

2:40–2:55

Auction Structures in Bidding Games

Jason Gaitonde, Seung Hyun Lee, and Charlie Pasternak
Yale University

In bidding games, players do not alternate moves according to a predetermined sequence, but instead bid for the right to move. Traditional bidding versions of two-player recreational games like tic-tac-toe and chess use a first-price auction: the higher bidder pays his own bid and moves next. We analyze the effect of using alternative auction structures, particularly in determining optimal strategies. To explicitly capture the complementarity of moving consecutively in such games, we introduce combinatorial auctions in which agents can bid on combinations of future moves.

3:00–3:15

Applications of Tropical Geometry to Strategic Game Theory

Michael Zanger-Tishler and David Brandfonbrener
Yale University

We present new research on the application of tropical geometry in strategic game theory, building on recent work of Baldwin and Kelmperer related to the product mix-auction. We analyze more general situations in which agents choose strategies to maximize a payoff function that depends on both their own and other player's actions and investigate a new way to model payoffs in strategic games in terms of tropical hypersurfaces built from mixed strategies, and explain how, in certain circumstances, this approach leads to simpler and more computationally tractable ways to study equilibria, when compared with the standard approach of proof by cases.

Wilson A **2:00P.M. – 3:55P.M.**

2:00–2:15

The Effect of Technology-Enhanced Lessons in the Math Classroom

Elly Couch
University of North Alabama

As a future math teacher, I am strongly encouraged to incorporate different forms of technology into my teaching methods as a way to enhance my students learning and keep my students attentive during class. Many school systems, and more specifically math classrooms, are adopting iPads, Chrome Books, and other forms of technology for their students to use in the classroom. Does using technology really help students understand the math concepts that are being taught? Our research seeks to determine if incorporating technology into a math classroom improves student understanding as compared to no technology. Specifically, we focus on a lesson about projectile motion incorporating a software simulation and a physical model with a flight computer, compared to a traditional lecture. In our technology-enhanced lesson, we taught students about projectile motion by going through the mathematical basics of projectile motion with a rocket flight simulation and a PowerPoint presentation. After the lesson, the students observed a live rocket launch to reinforce the lesson concepts. We attached a flight computer to the rocket to record flight data, and students used the data from the rocket flight to explore the essential mathematical concepts of projectile motion using the software simulation. Early results from regional high school and middle school classrooms indicate improvements as measured by pre-test and post-test assessments for both control and experimental groups.

2:20–2:35

Image Noise -vs- Curvature Noise

James Matuk
Duquesne University

Mathematical techniques for removing noise from images include partial differential equations, non-local methods that take advantage of self-similarity in natural images, and both convex and non-convex optimization techniques. These methods have been around for some time, and have seen varying degrees of success depending on the specific application at hand. Recent work by Bertalmo and Levine has demonstrated it might be more effective to denoise the curvature data of a noisy image, and then use this 'denoised' curvature information, which equates to denoised level lines, to reconstruct the denoised image. The goal of this research project is to investigate image curvature data using statistical tools in order to adapt existing denoising methods to handle this new framework. In this talk, I will give a brief explanation of the problem: image noise. Then an analysis of the noise in the corresponding curvature image will follow, along with an explanation of how image curvature data is used for denoising. Preliminary results will be shown.

2:40–2:55

A Variational Approach for High Dynamic Range Imaging

Kinardi Isnata

Duquesne University

In this talk, we present a variational approach for fusing information from a stack of image data consisting of short and long exposure images into a High Dynamic Range (HDR) image. The varying range of exposures allow for an HDR that possesses the desired visual information in various regions in the image (e.g. vibrant colors, sharp details, and a greater dynamic range of luminosity), which a regular camera cannot capture. We use a variational approach based on the framework proposed by Bertalmio and Levine (2013) for fusing exposure bracketed images. As this framework is less sensitive to misalignments than comparable techniques, it allows for fusing images that are not completely aligned as well as have spatially varying blur, a very common situation when the image content involves people.

3:00–3:15

Image Restoration

Zibusiso Ndimande

Benedict College

Image restoration is one of the most important areas of image processing. It is the reduction of degradations which usually occur during acquisition of the image. These degradation usually include errors in the pixel value or optical effects. Common optical effects include out of focus blurring or even blurring due to camera motion. In real life situations, when an image sent electronically from one place to another, via satellite or wireless transmission appear on the image output in different ways depending on the type of disturbance in the signal. Hence noise can be defined as any degradation in the image signal caused by external disturbance. So we usually know what type of errors to expect and the type of noise in the image. Salt and Pepper noise is one of the standard noise forms, can be caused by sharp, sudden disturbances in the image signal. So we choose three most appropriate methods to reduce this noise. We worked on images with different amounts of noise added. So our goal is to find out which one is the best filter to remove noises and create a clear an image with the least amount of noise in it.

3:20–3:35

The Beltrami Graph Partitioning Model and Its Efficient Primal-Dual Projected Gradient Algorithm for Image Segmentation

Jing An

University of California, Los Angeles

A general graph partitioning problem is to separate a dataset into k subsets of interest. However, challenges arise when the datasets are large-scale and high-dimensional, and common mathematical formulations of the problem are NP-hard. Here, we will introduce the Beltrami graph partitioning model, which is a new measure of optimality for clustering based on the Beltrami framework. The proposed model can be decomposed into inner and outer minimization problems. The outer optimization has been solved by the rearrangement algorithm, and the inner part can be solved more efficiently by the proposed primal-dual projected gradients method (PDPG). We will focus on the PDPG algorithm and discuss the boundedness of stepsizes to ensure the convergence. Moreover, we will present the model's application in image segmentation, and how it performs as bridging the edge- and region-based criteria, naturally.

Wilson B **2:00P.M. – 3:55P.M.**

2:00–2:15

Towards a Stability Theory for Feynman's Operational Calculus in the Purely Discrete Setting: A Direct Approach

Samantha Stanley
Creighton University

Given the monomial $P^{m_1,m_2}(z_1, z_2) = z_1^{m_1} z_2^{m_2}$, we use Feynman's operational calculus to compute the function $P^{m_1,m_2}_{\eta_1,\eta_2}(A, B)$ of the not necessarily commuting operators $A, B \in \mathcal{L}(X)$, where X is a Banach space and η_1, η_2 are purely discrete, finitely supported probability measures on $[0, 1]$ (which serve to specify when the operators act in products). Selecting sequences $\{\eta_{1,k}\}_{k=1}^{\infty}$, $\{\eta_{2,k}\}_{k=1}^{\infty}$ of purely discrete, finitely supported, probability measures on $[0, 1]$ for which $\eta_{j,k} \rightharpoonup \eta_j$, $j = 1, 2$, as $k \to \infty$, we wish to prove that $P^{m_1,m_2}_{\eta_{1,k},\eta_{2,k}}(A, B) \to P^{m_1,m_2}_{\eta_1,\eta_2}(A, B)$ as $k \to \infty$ in norm on $\mathcal{L}(X)$. With this result we can then show, for a sufficiently well-behaved function $f(z_1, z_2)$ of two complex variables, that $\lim_{k\to\infty} f_{\eta_{1,k},\eta_{2,k}}(A, B) = f_{\eta_1,\eta_2}(A, B)$. Finally, we are working to make a connection between the use of discrete and continuous time-ordering measures. We will accomplish this by selecting sequences $\{\eta_{1,k}\}_{k=1}^{\infty}$, $\{\eta_{2,k}\}_{k=1}^{\infty}$ of purely discrete, initely supported, probability measures on $[0, 1]$ for which $\eta_{j,k} \rightharpoonup \mu_j$, $j = 1, 2$, as $k \to \infty$, where μ_1 and μ_2 are continuous probability measures on $[0, 1]$. We wish to prove that $\lim_{k\to\infty} f_{\eta_{1,k},\eta_{2,k}}(A, B) = f_{\mu_1,\mu_2}(A, B)$. My talk will detail the progress made.

2:20–2:35

Statistical Analysis and Forecasting Solar Radiation in Arizona

Yao Li
Winona State University

The Arizona Meteorological Network (AZMET) has been taking measurements of various meteorological conditions including, but not limited to wind speed, evapotranspiration, and solar radiation. AZMET has had 38 different sites taking measurements, of which 15 stations has complete data from 1999 to the present. It is of particular interest to solar panel investors to know the future solar radiation outlook and exceedance probabilities for a given amount of solar radiation. This knowledge is useful to determine if a solar panel site would be profitable or useful. Our study aims to forecast solar radiation [J/m2] using a linear regression model that incorporates previous years of monthly average solar radiation and other weighted variables that influence radiation measured at the surface. In this presentation we will discuss data mining, significant factors in the prediction model, accuracy of the forecasting, and potential future research.

2:40–2:55

Rational Decision-Making Models of Conflicts in the 1990s

William O'Brochta

Hendrix College

The 1992 to 1995 Bosnian War provides an ideal outlet for the study of rational decision-making models proceduralized with game theory because of the diverse nature of its decisions and the relative prevalence of literature on its actors. Such a study attempts to expand on the applicability of game theory and decision theory toward the rationality of political conflict resolution. This study focuses on the Bosnian War in the hopes of evaluating the efficacy of rational decision making models, namely: the Rational Actor Model, Government Politics model, Poliheuristic model, and Theory of Moves. Goals of this study included explaining how and why different models could be successfully applied to different types of decisions, with emphasis on the Dayton Agreement and Srebrenica massacre. The hypothesis was that characteristics of the Government Politics model would make it the most accurate model for predicting decisions made during the Bosnian War; testing it required determining the personalities of actors, creating a comprehensive timeline of the War, developing utility theory in order to rank outcome preferences, geometrically justifying the use of game theory with five or more players, completing the analysis on Dayton and Srebrenica using all models, examining fair solutions using the Shapley value, and looking comprehensively at decisions made during the War to see if extrapolation from just two decisions is possible. Both the Rwandan Genocide and Tajikistan Civil War were considered as future studies and related situations. The Poliheuristic model, which considers the political feasibility of strategies, ended up holding the most promise for predicting actors decisions during conflicts similar to the Bosnian War.

3:00–3:15

Combinatorics And The Harmonic Structure of Musical Chord Sequences

Francis Mana-ay

Gonzaga University

It is becoming increasingly known there is great connection between mathematics in music. In this presentation, we examine particularly the connection between combinatorics and the harmonic structure of musical chord sequences, as written about in depth Cantone, et al. in their 2006 Conference Paper, "On Some Combinatorial Problems Concerning the Harmonic Structure of Musical Chord Sequences. We begin by transcribing musical vocabulary into mathematical definitions. From this new vocabulary we will build the formal definition of regular chord progressions and then examine problems concerning such chord progressions, resulting in various algorithms to explore their nature. We will discuss discoveries about the various aspects of these progressions, as well as their implementation and application. Finally, we conclude by presenting some of the open questions which arose as a consequence of these algorithms and the implications they have on the results and conclusions made.

3:20–3:35

Minimal Forcing Set Algorithm for a Single Vertex Flat-Foldable Crease Pattern

Samuel McLaren

Western New England University

This project explores work performed, in the field of origami, by the author and Tianna Procon, along with Dr. Thomas Hull, to develop a minimal forcing set for a single vertex flat-foldable crease pattern. A single vertex is a point where multiple crease lines join to form a pattern of angles, called a crease pattern. A flat-foldable crease pattern is one which does not violate a set of basic theorems. Given a fold assignment for a flat-foldable single vertex, a forcing set is a collection of crease lines that, when folded, force all other crease lines to fold as labeled. A minimal forcing set is the smallest of such. During this research the objective was to form and prove an algorithm which allowed a user to find the minimal forcing set of crease lines for a flat-foldable single-vertex crease pattern of any degree. An algorithm has been created and tested with numerous folds without fail.

3:40–3:55

Let's Build a Giant Icosahedron!

Brian Darrow Jr.

Southern Connecticut State University

The Southern Connecticut State University Mathematics Club constructed a giant regular icosahedron which was showcased at the Fall 2014 meeting of the Northeastern Section of the Mathematical Association of America (MAA). Our version of the 20-sided MAA logo stood over 20 feet tall and was the culmination of weeks of careful planning and construction by a team of SCSU math students and faculty. Before construction, the close study of the Platonic solid's complex geometry, including the presence and importance of golden rectangles, was necessary to ensure the final polyhedron's structural integrity. This talk will describe the process through which students and faculty were able to transform a bunch of PVC pipe and tarp into a model of one of the mathematical community's favorite objects.

PME Session #2

Wilson C **2:00P.M. – 3:55P.M.**

2:00–2:15

Fun with Numerical Ranges

Jane Coons

State University of New York at Geneseo

The numerical range, or field of values, of a matrix A is the set of all complex numbers of the form x^*Ax where x is a unit vector and x^* denotes the conjugate transpose of x. The numerical range of A has several interesting properties: it is compact and convex, it contains all of the eigenvalues of A, and more! Kippenhahn (1951) provided a classification of all possible shapes of the numerical range of a 3×3 matrix. We prove that the set of all numerical ranges of matrices with integer entries is equivalent to that of matrices with rational entries. Furthermore, we show that for each of Kippenhahn's possible classes of the numerical range of a 3×3 matrix, there exists an integer matrix with such a numerical range.

2:20–2:35

There's a Glitch in the Matrix!

Jack Jenkins

State University of New York at Geneseo

The numerical range of an $n \times n$ matrix M, also known as its field of values, is the subset of the complex plane $W(M) = \{x^*Mx : x \in \mathbb{C}^n, ||x|| = 1\}$. Numerical ranges are defined algebraically, but have rich geometric properties that have been the subject of intense mathematical research in the last fifteen years, although the origins of the field can be traced back to work done in the 1950s. It is well known that the numerical range of a matrix is a compact and convex region in the complex plane. Beyond this general description, depending on the matrix, the convex boundary of the numerical range can take on a variety of shapes, such as an ellipse, a polygon, or even the union of flat and curved portions, and the richness of these possibilities increases as the dimension of the matrix increases. The speaker will present a number of his new results on a classification of numerical range geometries that emphasizes the distinction between flat and curved portions on the boundary. Using these results, the stability of various classes of numerical ranges $W(M)$ under perturbations of the entries of the matrix M will be addressed.

2:40–2:55

Finite Fun with Numerical Ranges

Douglas Knowles

State University of New York at Geneseo

Let p be a prime number congruent to 3 modulo 4. We will work in the finite field $\mathbf{F}_p[i] = \{a + bi \mid a, b \in \mathbf{F}_p\}$, where $\mathbf{F}_p = \{0, 1, ..., p-1\}$ and $i = \sqrt{p-1} = \sqrt{-1}$. Let A be a matrix with entries from $\mathbf{F}_p[i]$. Let $\bar{x}^T$ denote the conjugate transpose of x. Consider a number $k \in \mathbf{F}_p$. Let S_k be the set of all vectors x with entries in $\mathbf{F}_p[i]$ where the product $\bar{x}^T x = k$. The author has created a definition of a new concept, the k-numerical range $W_k(A)$, which is the set of numbers of the form $\bar{x}^T Ax$, for all x in S_k. We investigate the properties of these k-numerical ranges, and explore the fundamental differences between $W_0(A)$ and $W_k(A)$ for nonzero k. We will then discuss our pioneering work in classifying the shapes $W_1(A)$ can take. This includes the author's proof that $W_1(A)$ can be a union of concentric circles.

3:00–3:15

Pushing the Bounds of Numerical Ranges

Rayanne Luke

State University of New York at Geneseo

The numerical range W of an $n \times n$ matrix M with complex entries is the compact and convex subset of $\mathbb{C}$ defined as $W(M) = \{x^*Mx : x \in \mathbb{C}^n, ||x|| = 1\}$. An integer lattice point is of the form $a + bi$, where a and b are integers. Seeking invariant upper bounds for the area of and number of lattice points contained within the numerical range, we begin by finding the exact area of the numerical range of a 2×2 matrix, whose shape is an ellipse and area is easily calculable. Generalizing to upper area bounds for any size matrix, we circumscribe the numerical range by a circle. To provide a universal bound, we define a translation to ensure that the numerical range contains the origin. Thus, we arrive at the author's new proof of an upper bound for the area of the numerical range of any matrix, where the formula is expressed in terms of the trace of the matrix. The trace of a matrix is defined as the sum of the diagonal entries. We also use the trace of the matrix to bound the number of integer lattice points contained within the numerical range.

3:20–3:35

Properties of The First Hurwitz Equation

Josiah M. Banks

Youngstown State University

The *Hurwitz Equation* is a Diophantine equation of the form $x_1^2+x_2^2+x_3^2+\cdots+x_n^2 = ax_1x_2x_3\cdots x_n$ where a and x_i are positive integers for each $i = 1, 2, \ldots, n$. This equation has been studied by many great mathematicians. In this talk, we present original research on the Hurwitz Equation with $a = 1$, and discuss divisibility properties as well as operations to generate an infinite number of solutions. We also look at how the solution space forms an infinite group and identify fixed divisors of the orbits of the group. Lastly, we will present unproven conjectures formed in the process of research.

3:40–3:55

On a Local-Global Property of Quadratic Residues

Jenna L. Wise

Youngstown State University

It is well known that not every property that holds in local fields (such as $\mathbb{Z}_p$) translates to be true in global fields. For example, the congruence $(x^2 - 2)(x^2 - 3)(x^2 - 6) \equiv 0$ (mod p) has a solution in $\mathbb{Z}_p$ for all primes p, but the corresponding diophantine equation $(x^2 - 2)(x^2 - 3)(x^2 - 6) = 0$ has no solutions in $\mathbb{Q}$. In this talk we will discuss whether an integer being a square residue for "many" primes must necessarily be a square of an integer. We will give a positive answer for this question.

Wilson B **4:00P.M. – 6:15P.M.**

4:00–4:15

Intervention Model for Malaria

Taylor McClanahan
University of Arkansas at Little Rock

Every year about 300 million people are infected by malaria, an infectious disease caused by Plasmodium spp. parasites. Nearly 660,000 deaths occur. Malaria spreads through a criss-cross infection process in which infected female Anopheles mosquitoes transmit the parasite to susceptible humans through their salivary glands. Mosquitoes also become infected by biting infected humans. Mosquito elimination, avoidance of mosquitoes, sleeping nets, and spraying insecticides are a few methods to retard the spread of malaria. My project focused on the impact of sleeping nets in reducing malaria in sub-Saharan countries in Africa. A mathematical model was constructed and simulated by using eight differential equations. A set of inequalities were derived that give necessary and sufficient conditions under which the disease would become endemic in a population. If 20% of the people used sleeping nets, the infectious populations die. Additionally, with 100% net usage, a sleeping net only needed to be 24% effective for the infectious populations to die. These inequalities and results highlight the role that the use of sleeping nets play in suppressing or diminishing a malaria outbreak.

4:20–4:35

Warfarin Dose Prediction by Building a Pharmacokinetics-pharmacodynamics Mathematical Model

Yu Fu
University of California, Irvine

In this project, a mathematical model is built to predict dose for warfarin, one of the most widely prescribed anticoagulant drugs in North America. Even a mild amount of overuse of warfarin might cause bleeding and therefore, such a model can help people get access to dose individualization. An exponential decay model is used to show how different clinical factors such as age and body weight influence pharmacokinetics of warfarin, the concentration-time relationship. A Sigmoid Emax model is adopted to examine pharmacodynamics of warfarin, the concentration-effect relationship. Finally, we link pharmacokinetics and pharmacodynamics of warfarin with a PK-PD model and show how the decrease of clotting factors causes an increase in INR, the index used to detect blood clots.

4:40–4:55

Dynamics of Ateles Hybridus Populations in Non-Fragmented and Fragmented Landscapes: A Discrete Mathematical Model

Matthew Buhr
University of South Dakota

Mathematical modeling is a branch of mathematics studying the behavior of systems and maps in a current state using past events. In this study, we create a mathematical model to estimate the dynamics of Ateles Hybridus, also known as the Brown Spider Monkey, in a non-fragmented and fragmented landscape. Typically, females give birth to only a single baby every one to five years. Young monkeys depend completely on their mothers for about ten weeks, but after that time they begin to explore on their own and play amongst themselves. Ateles Hybridus have undergone endangerment situations for several years. Our goal is to model the dynamics of Ateles Hybridus given their population structure and lifestyle. We first develop a single-patch model to model the dynamics of Ateles Hybridus populations in a single patch. Then, we consider a forced migration parameter of young females at the time of their sexual maturity and add new parameters into our single-patch model to account for differences in patch quality, given by hostility and by size. We take various parameters into account, including survival probabilities of every cohort of Ateles Hybridus, the birth gender probability, and the rate of reproduction. We aim to develop solutions to the endangerment issue, and provide feedback based on our mathematical model and testing.

5:00–5:15

Modeling the Spread of an Infectious Disease in a Semi-closed Environment

Crystal D. Mackey
Youngstown State University

In the last few years, several eradicated diseases have emerged and spread, particularly in colleges and universities across the United States. We focus on the mumps outbreak at Ohio State University (OSU). A model is being developed to represent the student population at OSU using a cellular automaton. This model has two sub-models. The first sub-model is the movement of students from one building to another building. The second sub-model occurs inside the classroom and we track where the students sit in relation to each other and the chance of transmission. Factors that contribute to the outbreak of mumps include being in a crowded environment like attending the same class, playing on the same sports team or living in a dormitory with someone who has mumps. The model was developed to assume a semi-constant population because the majority of OSU students are non-commuters and live on campus.

5:20–5:35

Neurons as Dynamical Systems

Eric J. Stone
Youngstown State University

Neurons play an important role in many of our bodily functions. We will present solutions of a system of first order non-linear differential equations and fundamental circuit theory to investigate the dynamical activity of a neuron in various states.

5:40–5:55

A Bone Eat Bone World: Math Models of Bone Metabolism

Gabrielle K. Van Scoy
Youngstown State University

Bone mass and density are regulated by bone cells (osteocytes, osteoblasts, and osteoclasts) in response to stress on the bone. It is understood that micro fractures within bone increases communication among cells, which allows new bone to replace damaged cells. A biomedical engineering lab at the University of Akron is developing experiments to better understand the ways and methods of bone metabolism (resorption and formation) in response to stress on the bone. Discrete Stochastic Mathematical models are constructed to aid in the understanding of the bone resorption and the bone replacement processes. These models are ideal because they allow for the tracking of the decisions made by each individual bone cell as opposed to the average activity for a large group of bone cells. In addition, they are very flexible to new or changing information which tends to be the trend in biological experiments. Progress on the above described mathematical models will be presented and future work mentioned.

6:00–6:15

An Agent-based Model of *Eleutherodactylus coqui* on the Big Island of Hawaii

Megan J. Chambers
Youngstown State University

Eleutherodactylus coqui, commonly known as the coqui frog, is a species of tree frog native to Puerto Rico. They are characterized by the males' loud, high-pitched "ko-kee" mating call. Around 1988, the frog was accidentally introduced to the state of Hawaii and soon became a largely problematic invasive species. Since its introduction, various groups' efforts have managed to control and largely eradicate the coqui populations on almost all of the Hawaiian Islands. On the Big Island, the population remains out of control. This agent-based model simulates the population spread of the coquis in an environment and endeavors to find a more effective control strategy for this invasive animal.

Wilson C **4:00P.M. – 6:15P.M.**

4:00–4:15

The Duel of Finite Groups and the Rationals: the Inverse Problem of Galois Theory

Jasmine Burns
Eastern Washington University

Is every finite group the Galois group of a Galois extension of the rational numbers? The central problem of modern Galois Theory involves the inverse problem: given a field k and a group G, construct an extension ${}^{L}/{}_{k}$ with Galois group G. In this paper we observe major breakthroughs on the Inverse Problem of Galois theory up to present time while reviewing some major concepts in Galois Theory. Basic examples will be given for the case of simple groups with a brief touch on the Galois Embedding Problem which is an approach to the Inverse Problem in the case of non-simple groups.

4:20–4:35

Galois Groups of Degree 15 p-adic Polynomials

Jessica Weed
Elon University

Polynomials whose coefficients are p-adic numbers play a central role in abstract algebra and number theory. A classical result states that given a prime number p and a positive integer n, there exist only finitely many "distinct" degree n polynomials with p-adic coefficients. Researchers have therefore focused on methods for counting the number of such polynomials as well as computing useful characteristics of each polynomial. One of the most important such characteristics is the polynomial's Galois group, an object which encodes arithmetic information concerning the polynomial's roots. The most difficult cases arise when the prime p divides the composite degree n. In this case, past research has dealt with all degrees less than or equal to 14. Therefore, our research focuses on degree 15 polynomials. In this talk, we will give a brief introduction to p-adic numbers and Galois groups. We will conclude by discussing our newly-developed methods for computing Galois groups of degree 15 polynomials with 5-adic coefficients.

4:40–4:55

Factoring Groups using Generalizations of the Direct Product

Gary DeClerk
Hendrix College

We examine two generalizations of the direct product: the semidirect product, which is already well-researched; and the weave product, which is introduced in this talk. Our examination includes a look at the necessary conditions to combine two groups into a larger group and to factor a single group into smaller groups using each of these products, along with general patterns in the groups made with each of these products.

5:00–5:15

Counting Cayley-Sudoku Tables

Kate Lorenzen

Juniata College

A group G is a set of objects for which a binary operation that satisfies certain conditions is defined. A Cayley table for G represents the binary operation of the group. Because of the conditions on the binary operation, every element of the group appears exactly once in every column and every row. This requirement is one of the rules of placing numbers in the popular game Sudoku. In addition, a Sudoku table requires each element to appear exactly once in every inner box. A Cayley-Sudoku table is a Cayley table that follows the rules of a Sudoku table. Carmichael, Schlowman, and Ward in Cosets and Cayley-Sudoku Tables examined ways to construct a Cayley-Sudoku table and we use one of these methods. In particular, we count the number of unique Cayley-Sudoku tables for a given $\mathbb{Z}^n$. Some of these tables have the special property that one can be obtained from another by interchanging rows and columns. We determine what conditions are necessary for this to occur in order to accurately count how many such tables there are.

5:20–5:35

On Subgroups of Semi-direct Products

Michael Schroeder

St. Olaf College

In 1889, Goursat published a paper that established a correspondence between subgroups of a direct product $A \times B$ and triples of the form $(U_1/U_2, H_1/H_2, \sigma)$ where $U_2 \triangleleft U_1 \leq U$, $H_2 \triangleleft H_1 \leq H$, and $\sigma : U_1/U_2 \to H_1/H_2$ is an isomorphism. About a hundred years later in 1991, Usenko published a paper that established a correspondence between subgroups of a semi-direct product $U \rtimes_\phi H$, where $\phi : H \to \operatorname{Aut} U$, and triples of the form (L, R, θ) where $L \leq U$, $R \leq H$, and $\theta : R \to U$ is a derivation (or crossed homomorphism) with special properties. While Goursat's theorem has been used many times to investigate subgroups of direct products, Usenko's theorem has not, probably due to the computational complexity of finding the special derivations. In our paper, we find ways of reducing the computational complexity under certain conditions and use Usenko's theorem to determine the subgroups of certain metacyclic p-groups.

5:40–5:55

Frobenius Problems in a Commutative Ring with Identity

William Linz
Texas A&M University

The classical Frobenius problem asserts the following result: if a_1, a_2, ..., a_n are coprime positive integers (i.e. that $\gcd(a_1, a_2, \ldots, a_n) = 1$), then there is a greatest positive integer $N(a_1, a_2, \ldots, a_n)$ such that for any $k > N(a_1, a_2, \ldots, a_n)$, there are nonnegative integers b_1, b_2, ..., b_n such that $k = a_1b_1 + a_2b_2 + \cdots + a_nb_n$, but no such representation for $N(a_1, a_2, \ldots, a_n)$. In the case $n = 2$, it is also known that $N(a_1, a_2) = a_1a_2 - (a_1 + a_2)$. Johnson and Looper have generalized this result to commutative rings with identity. Let R be such a ring, C a nonzero semigroup in R, U a semigroup in R, and A a nonempty subset of R not containing 0. We define a sequence $\alpha_1, \alpha_2, \ldots, \alpha_n \in A$ to be *admissible* (with respect to C and U) if and only if

$$S(\alpha_1, \alpha_2, \ldots, \alpha_n) = \left\{ \sum_{i=1}^{n} \lambda_i \alpha_i \mid \lambda_1, \ldots, \lambda_n \in C \right\} \subseteq U.$$

The Frobenius problem associated with a given admissible sequence $\alpha_1, \ldots, \alpha_n$, and semigroups C and U is to determine the set $\{w \in S(\alpha_1, \ldots, \alpha_n) \mid w + U \subseteq S(\alpha_1, \ldots, \alpha_n)\}$. We solve some instances of the Frobenius problem in $R = \mathbb{Z}[\sqrt{2}]$ and consider $\mathbb{Z}[\sqrt{m}]$ for squarefree m other than 2.

6:00–6:15

Generalizing Cayley Digraphs

Matthew Devery
St. John's University

Cayley digraphs were invented to be a pictorial representation of groups, but can they be generalized to other algebraic structures? We will explore a generalized version of Cayley digraphs and their corresponding loops, which are group-like structures without associativity.

Wilson B **8:30A.M. – 11:45A.M.**

8:30–8:45

Life Annuties

Megan Alaimo
Western New England University

If you are lucky enough to win the lottery, have you considered how you might receive your winnings? An annuity, a series of steady equal payments, is frequently used to pay large sums of money, such as lottery winnings and retirement payments. In this talk, we will discuss the major differences between an annuity certain and a life annuity, including what happens if the annuitant passes away and whether or not life expectancy is taken into account in order to calculate the number of payments. We will also consider how the age and health of the annuitant is taken into account and can affect the present value of the annuity. Finally, we will discuss how the mortality fracture changes the present value of a life annuity.

8:50–9:05

Chaotic Models of the BZ Reaction

Steven Dabelow
McNeese State University

In recent decades, the study of non-linear dynamical systems has become increasingly prevalent in fields such as mathematics, engineering, biology, and economics. This increased study in the field of chaos also includes chemical oscillators, reactions that can transition between multiple states repeatedly. The Belousov-Zhabotinskii (BZ) reaction is one example of such a non-linear system that exhibits this oscillatory behavior. Our question is if we were to model the mechanisms that describe the BZ reaction, since there are multiple ways to define the reaction, which ones would be chaotic. We will discuss briefly two of the major ways to describe the reaction, the Oregonator and the Brusselator, and see how they are, or could be, chaotic by modeling the systems of differential equations using MATLAB.

9:10–9:25

Recognition of Textural Differences in Infrared and Ultraviolet Images Using Fractal Characteristics

Jack Ryan
North Central College

Due to their complexity, many natural phenomena cannot be completely analyzed using Euclidean geometry. In light of this, the study of fractals is especially salient when examining nature. An algorithm written by Troy Thielen was utilized to estimate the fractal dimension and lacunarity of new ultraviolet and infrared images. The process of aligning the mutli-spectral images so that they line up correctly was a significant, crucial component of the project, due to the way that light bends in the different spectrums; the images did not line up correctly without intervention. The fractal characteristics of these images were then to be analyzed to recognize textural differences, a useful method when attempting to locate objects; however the algorithm was found to be insufficient in dealing with the complex inputs. Instead, this project provides a foundational method for image registration that can be used for future research projects.

9:30–9:45

Magnetic Spectral Decimation on Self-Similar Fractals

Madeline Hansalik
Texas A&M University

Malozemov, L and Teplyaev, *A Self-similarity Operators and Dynamics* Mathematical Physics, Analysis and Geometry **6** (2003) 201218, discusses how spectral decimation of the Laplacian of infinite self-similar graphs is possible. In this talk we will discuss how the ideas of this paper can be extended to infinite self-similar graphs with magnetic fields imposed.

9:50–10:05

Swivel Chairs and Such: A Mathematical Standpoint on Mechanics in Everyday Activities

Ryan DeElena
Texas State University

When one chops down a tree, how can he determine towards which direction it will fall? When one goes bowling with his friends, what can he do to increase his chances of scoring well? When one comes in contact with a swivel chair, how can he spin around without getting nauseous so quickly? Answers to these will be presented along with basic physical justifications.

10:10–10:25

Space Physics

Niyousha Davachi
University of Texas at Arlington

Changes in the solar wind can influence our daily lives and advanced technologies. They can impact GPS satellites, air-traffic control, space flight, and even create blackouts. We can take precautions if we have advance and accurate notice of a major solar storm headed our way. In Space Physics we try to understand how changes in the solar wind affect us. In this project we are observing sudden changes data in solar wind behavior and mathematically determining the changes in the equatorial magnetic field of the Earth at the point closest to the Earth-Sun line.

10:30–10:45

Optimization of a Nonlinear PID Loop

Michael A. Baker
Youngstown State University

Proportional-integral-derivative (PID) controllers calculate the error between an experimental observable and its desired value. These PID loops allow for a system to maintain a desired temperature based off past readings. In this talk, we mathematically examine optimizing a PID loop for a system of interest. We also examine geometric interpretations of the noise with respect to the control loop.

10:50–11:05

Unique Hamiltonicity and Computational Algebraic Geometry

Monica E. Busser

Youngstown State University

For decades graph theorists have considered questions of unique Hamiltonicity in different types of graphs. For example, Sheehan's Conjecture, posed in 1975, claims that there does not exist a uniquely Hamiltonian 4-regular graph. This remains an open question. We will discuss how methods of computational algebraic geometry, specifically Gröbner bases and standard monomials, can be applied to this problem to check lists of 4-regular graphs for unique Hamiltonicity. We will also discuss unique Hamiltonicity in 3-connected and 4-connected graphs.

11:10–11:25

Cellular Automata and Shrinking Cities: An Investigation of the Spatial Distribution of Blight in Youngstown, Ohio

Eric A. Shehadi

Youngstown State University

Youngstown, Ohio, a city found in the affectionately labeled "rust belt," is a shrinking city plagued by thousands of vacant homes. Since the crash of its steel economy in the 1970s, Youngstown has lost over half of its population. This has led to mass abandonment of homes which severely inhibits the health of several of Youngstown's neighborhoods. Geospatial statistics are employed to investigate the spatial distribution of vacant homes. Additionally, a cellular automata model is presented that attempts to simulate the distribution and emergence of highly damaged neighborhoods. Finally, the cellular automata model is compared and calibrated with vacancy survey data collected in Youngstown with the goal of creating a platform to compare the effectiveness of city programs, policies, and strategies to maximize the city's efforts and funds.

11:30–11:45

The Ultimate Mind-Bender: Futurama's Mind-Switching Problem

Zack While

Youngstown State University

In a critically acclaimed episode of Futurama, a mind-switching machine is created with a catch: two bodies can only swap minds once. After realizing the dilemma of putting everyone back in their original bodies, one character figures out a strategy to fix the situation. In this talk we will explore the solution presented during the show, known as Keeler's Theorem, named after the PhD mathematician Ken Keeler who wrote the episode.

Wilson C **8:30A.M. – 11:45A.M.**

8:30–8:45

Three-factor Polynomials, a Diophantine Equation, and Building a Bigger Box

Gregory Convertito
Trinity College

Beginning with the generalization of a basic optimization problem from Calculus I, we attempted to find all possible rational solutions assuming integer initial conditions. We further generalized this problem to that of finding all integer coefficients A, B of the three-factor polynomial $y = x(x^m - A)(x^m - B)$ such that the roots of the polynomial are nth-roots of rational numbers; this reduces to solving the Pythagorean-like Diophantine equation $a^2 + kb^2 = c^2$ (k a fixed integer), for a, b, c natural numbers. We solved this by generalizing a classical method of generating Pythagorean triples, producing a number of cases involving the equivalence of k modulo 4 and the parity of the generating pair.

8:50–9:05

q-Thunsdorff's Inequality

Andrew Lacy
University of North Florida

A brief introduction to one type of Quantum Calculus is given, namely, q-Calculus which is a type of calculus formed without the notion of limits. The relationship and differences between ordinary calculus is briefly discussed. From here, some basic results in q-calculus are introduced, which are typically analogues to familiar results in the ordinary calculus, namely, differentiation, integration, etc. as well as their properties. From these results a quantum analogue of Thunsdorff's Inequality, which is an integral inequality based on convex functions, is stated and proved. This result is original work formed during a Capstone Experience course.

9:10–9:25

On the Morphology of Arithmetic Sums of Cantor Sets

Sharat Chandra
University of California, Irvine

It has been shown that given parameters $(\lambda, \gamma) \in [0,1] \times [0,1]$ corresponding to middle-λ Cantor set, C_λ, and middle-γ Cantor set, C_γ, the arithmetic sum of $C_\lambda + C_\gamma$ is a Cantor set if (λ, γ) is close to the origin, while the sum contains an interval if (λ, γ) is far away from the origin. However, there exists a mysterious region in the parameter space, R where the morphology was unknown. Boris Solomyak showed that for almost every point in R, the sum of the corresponding Cantor sets contained an interval. Generalizing to more complex Cantor sets, and extending Solomyak's argument, we consider two-parameter affine Cantor sets $C_{(\alpha,\beta)}$: Cantor sets where the thicknesses of the two generating sets are α and β respectively. We analyze the morphology of the sum of the standard $1/3$ Cantor set with $C_{(\alpha,\beta)}$ and find in the $\alpha - \beta$ parameter space, there again exists a mysterious region where the morphology is unclear. We show for almost every point in the parameter space, the sum does contain an interval.

9:30–9:45

An Extension of a Theorem of Polya

Anna Snyder
Hope College

An old theorem of G. Polya looks at the level curves of certain polynomial expressions and the intersection of such curves with lines of positive slope. We extend Polya's theorem and also consider the intersections of such curves with lines of negative slope.

9:50–10:05

Real Algebraic Level Curves and the Intersection of Lines of Positive Slope

Sarah Hilsman
Hope College

We consider the structure of the real algebraic curve

$$F(x, y) = \sum_{k=0}^{m} b_k f^{(k)}(y) x^k = 0$$

where $f(y) = \sum_{k=0}^{m} a_k y^k; a_m \neq 0$ and the b_k are the coefficients of $h(x) = \sum_{k=0}^{n} b_k x^k; b_n \neq 0$. G. Polya showed that under the conditions that f has only real zeros and h has only negative real zeros, the curve passes through any line of positive slope m times. We discuss the structure when the conditions on f and h are relaxed.

10:10–10:25

On the Structure and Calculation of a Class of Infinitely Nested Radicals

John Vastola
University of Central Florida

Most of the results on infinitely nested radicals are for radicals with positive "coefficients." Efthimiou, however, was able to calculate a certain class of periodic radical (with all of the coefficients positive or negative) using a trigonometric formula, and to identify these radicals with the fixed points of the Chebyshev polynomials. We consider the more general problem of calculating periodic radicals with all coefficients positive or negative n, for some complex number n; in similar fashion, we will identify these radicals with the fixed points of the iterates of a certain polynomial. We will examine the permutation group structure on the set of fixed points of this polynomial that arises by considering invertible maps that take fixed points to fixed points. The computational techniques suggested by this analysis will be discussed, and applied to a few examples. Some comments will be made on the application of these techniques to more general nested radicals.

10:30–10:45

Understanding Riemann Surfaces

Tianxia Jia

Winona State University

Riemann Surface is nowadays considered as the natural setting for studying the global behavior of complex-valued function. Especially, Riemann Surface is extremely helpful for visualizing the elementary complex-valued functions. However, it is quite a challenging task for undergraduate students without background in topology to understand Riemann Surface in their complex analysis classes. And the basic concepts of Riemann Surface are always beyond the scope of undergraduate complex analysis classes. Fortunately, Riemann surfaces for elementary complex-valued functions can be captured using an informal approach. The purpose of this presentation is to demonstrate informal but understandable methods producing Riemann surfaces for different elementary complex functions based on their certain properties.

10:50–11:05

Convex Optimization Methods for the Smallest Intersecting Ball Problem

Daniel Giles

Portland State University

The smallest intersecting ball problem involves finding a ball with minimal radius necessary to intersect a finite number of convex sets. This talk presents effective numerical algorithms for solving the smallest intersecting ball problem in which the given convex sets are of particular shapes. The methods are based mainly on the majorization minimization principle, the log-exponential smoothing technique, and Nesterov's accelerated gradient method. Numerical tests and comparisons among the methods are also presented.

11:10–11:25

Cavalieri's Principle for Surface Area

John Tucker

SUNY Fredonia

Historically, Cavalier's Principle provided a method for computing volumes before the invention of calculus. Unfortunately, the ideas employed by Cavalieri and his contemporaries did not deal with surface area. This talk will use calculus techniques to investigate the surface areas of a number of transformed objects and present some results in the spirit of Cavalieri.

11:30–11:45

Geometry to Number Theory: Minkowski's Theorem

Elliot Golias

Kent State University

A beautiful subject in mathematics, discrete geometry reveals many fundamental connections between geometry, analysis, algebra and analysis through the study of simple geometric objects. Laying at the foundation of the study of the geometry of numbers, Minkowski's Convex Body Theorem elegantly reveals such a connection between geometry and number theory. We will explore an application of Minkowski's Theorem by showing that any integer may be written as the sum of four perfect squares.

PME Session #7

Wilson B **2:00P.M. – 3:55P.M.**

2:00–2:15

A Search for Record-breaking Linear Codes over Galois fields up to $GF(13)$

Derek Foret

Kenyon College

Constructing codes with the best possible parameters is one of the fundamental and challenging problems in coding theory. There are well-researched databases of best-known codes over finite fields of sizes up to nine, while new databases of best known codes over the alphabets $GF(11)$ and $GF(13)$ having recently been introduced. Quasi-twisted codes (and their special subset constacyclic codes) are a promising class of linear codes that have been shown to produce new record-breaking codes (codes with better parameters than the best-known codes in the databases mentioned above). In this work, we devise a pseudo-exhaustive search algorithm for constacyclic codes over these fields. We then take our best results to search for quasi-twisted codes over those same fields. New record-breaking codes found using both methods will be presented.

2:20–2:35

Quantum Key Distribution Protocol

John Mangles

Creighton University

Quantum key distributions (QKD) have become a topic of significant interest in quantum computing. A QKD is a technique in quantum cryptography for creating a completely random key for transferring information. The potential for truly secure data transfer is an important area of work in quantum cryptography, but it is subject to noise in the system that can disturb the key. Thus there is a need for a completely device independent quantum key distribution protocol. We will present several examples of QKD and some results related to device independent QKD accomplished in a noisy environment.

2:40–2:55

On the Minimal Reset Words of Synchronizing Automata

David Stoner

South Aiken High School

Cerny's Conjecture is a 50-year old question which concerns the combinatorial field of synchronizing automata. In particular, it postulates that the maximal length of the minimal reset word among all n-state automata is $(n-1)^2$. A proof is presented for Pin's Theorem, which applies Cerny's conjecture to p-state automata consisting of a cycle and a non-permutation, where p is an odd prime. Also, families of automata of the form $F(p,k)$ are introduced; they consist of a cycle and a group of k disjoint merging arcs. $C(p,k)$ is defined to be the maximal length of minimal reset words within these families. A lower bound of $C(p,k)$ for general k is demonstrated, and the exact value of $C(p,2)$ is found. These results are presented in two original theorems. In order to prove these statements, a connection is discovered between the structures of automata within $F(p,k)$ and the cyclotomic field $\mathbb{Z}[\omega_p]$.

3:00–3:15

Optimizing Course Offerings with Genetic Algorithms and Particle Swarm Optimization

Phillip Barbolla
Roanoke College

Evolutionary algorithms are a versatile and unique class of problem-solving methods inspired by natural processes. Genetic algorithms and particle swarm optimization, specific techniques within the umbrella of evolutionary algorithms, are based on the processes of natural selection and swarming populations respectively. The algorithms mathematically mimic nature to tackle especially difficult optimization problems. This research project applied genetic algorithms and particle swarm optimization to the problem of scheduling. The goal is to develop a system that can minimize potential conflicts in the mathematics, computer science, and physics department course offerings, adaptable to other departments and institutions.

3:20–3:35

Monomial Solutions to Generalized Yang-Baxter Equations in Low Dimensions

Andrew Nemec
Texas A&M University

Unitary solutions to the Yang-Baxter equation are important to quantum information science because they lead to unitary representations of the braid group, which can be used to design quantum logic gates that make up topological quantum circuits. By finding new unitary solutions to the Generalized Yang-Baxter equation in low dimensions and classifying them, we will be able to find new representations of the braid group which may lead to new designs for quantum logic gates used in quantum computers. Because it is extremely difficult to find solutions to the Generalized Yang-Baxter equation, we will narrow our search to set-theoretical solutions, that is, solutions that are also permutation matrices.

3:40–3:55

A Mathematical Framework for Evaluating a Cost-effective Balance of Human Trafficking Prevention and Aid Resources

AJ Vogt
Duquesne University

Human trafficking is the modern-day form of slavery. Human trafficking occurs on a daily basis throughout the United States with the majority of victims being women and children. Existing programs to reduce human trafficking are primarily focused on either the prevention of first-time victims or the aid of previously victimized individuals. In this study, we propose a mathematical model describing human trafficking of underage females and the use of prevention and short and long-term aid programs to reduce victimization. The model is a system of differential equations describing the movement of underage females between susceptible, victimized, and aided classes within an at-risk population. Prevention programs are included in the model as a reduction in the rate at which susceptible females are victimized. Both short and long-term aid programs move victims to separate classes in the model. The costs of implementing prevention and aid are estimated to reflect existing programs. Model solutions show the number of trafficking victims (both first-time and repeat victims) and the total costs associated with prevention and aid programs, respectively. Our goal is to use the mathematical framework to determine an appropriate balance of prevention and aid resources that minimizes both total costs and total number of victims over a given period of time.

Wilson B **2:00P.M. – 3:55P.M.**

2:00–2:15

Nim on Tree Graphs

Bryce Christopherson
Augustana College

Edge Nim is a combinatorial game played on regular graphs with positive, integrally weighted edges. In play, two players alternately begin from a fixed starting vertex and move to an adjacent vertex, decreasing the weight of the incident edge to a strictly non-negative integer as they travel across it. The game ends when a player is confronted by a position where no incident edge has a nonzero weight (or, that is to say, when the player is unable to move). In the normal form, this player loses, and in the Misere form, this player wins. There has been headway toward determining which games are winnable, particularly on acyclic graphs; Fukuyama previously described a method to determine Grundy numbers for a given position, and Clark proposed a solution to the problem using a pruning process. We present an alternative approach to edge Nim on tree graphs, which reveals two curious algebraic structures tied up in the process. This method allows for the game to be completely solved in both forms, and produces a more computationally inexpensive algorithm to determine the winner and their moves. Traveling down this avenue also raises the alluring possibility that there may be further ties between strange algebraic structures and games on graphs, which we find enjoyable to consider.

2:20–2:35

Total Prime Labeling for Wheel Graphs

Adelin Levin
Grand Valley State University

Total prime labeling for a graph with n vertices and k edges is possible if and only if each integer from 1 to $n + k$ can be assigned to exactly one edge or vertex such that every pair of adjacent vertices has labels that are relatively prime, and, for each vertex, the labels assigned to its incident edges are setwise relatively prime. Such a graph is said to be a total prime graph. To date, total prime labeling has been explored for only a small handful of graph families. We give a brief history of total prime labeling and demonstrate that all wheel graphs W_n are total prime graphs.

2:40–2:55

Graph Pebbling and Graham's Conjecture

Cole Watson
Hope College

Graph pebbling is a game on a connected graph G in which pebbles are placed on the vertices of G. A *pebbling move* consists of removing two pebbles from any vertex and adding one to an adjacent vertex. A configuration of pebbles is *r-solvable* if for a given target vertex r, there is a sequence of pebbling moves so that at least one pebble can be placed on r. The *pebbling number* of a graph G is the smallest integer $\pi(G)$ such that any configuration that uses $\pi(G)$ pebbles is *r-solvable* for any $r \in V(G)$. A long standing conjecture in graph pebbling is Graham's Conjecture. It states that given any two graphs G and H, $\pi(G\Box H) \leq \pi(G)\pi(H)$, where $G\Box H$ is the Cartesian product of graphs. A graph G satisfies the *two-pebbling property* if two pebbles can be placed on any vertex $v \in V(G)$ given any configuration of $2\pi(G) - q + 1$ pebbles, where q is the number of vertices that have at least one pebble. The smallest known graph that does not satisfy the two-pebbling property is called the Lemke graph (L). We will show that Graham's conjecture holds for such families as $L\Box K_n$ and several others.

3:00–3:15

Minimum Rank for Disconnected Circulant Graphs

Hayley Bertrand

St Norbert College

The minimum rank problem is to determine, for a given simple graph, the smallest rank of a Hermitian matrix whose off-diagonal zero-nonzero pattern is that of the adjacency matrix of the graph. When the graph in question is a circulant graph, there is a connection between polynomials with few terms, orthogonal representations of the graph in few dimensions, and positive semidefinite matrices with small rank. In this talk, we explore various connections between circulant graphs with multiple components, as well as their associated polynomials.

3:20–3:35

Minimum Rank of Circulant Graphs

Sam Potier

St. Norbert College

The minimum rank problem is to determine, for a given simple graph, the smallest rank of a Hermitian matrix whose off-diagonal zero-nonzero pattern is that of the adjacency matrix of the graph. When the graph in question is a circulant graph, there is a connection between polynomials with few terms, orthogonal representations of the graph in few dimensions, and positive semidefinite matrices with small rank. In this talk we discuss how the cyclic orders of complex roots of unity give equality in the minimum positive semidefinite circulant rank of certain related circulant graphs.

3:40–3:55

Flying Napoleon Triangles

Kadie Clancy

Washington & Jefferson College

Napoleon's Theorem is a widely known and often rediscovered geometric result that has been proved using of a variety of different mathematical techniques. The theorem states that if equilateral triangles are constructed on the sides of an arbitrary triangle, the centroids of these triangles themselves form an equilateral triangle. By use of complex numbers, proofs of this theorem and its generalizations become particularly simple and intuitive. The theorem can be generalized beyond the fact that only the centroids of the constructed triangles form an equilateral triangle. In fact, any similarly located points within the external triangles will form a Napoleon Triangle. In this presentation, we explore Napoleon Triangles created by similarly located points both within and outside of the external triangles. We prove that flying these similarly located points about will both collapse the triangle to a single point and expand the area of the triangle to infinity depending on the selected location of the similarly located point. We then extend this result to explore similar triangles constructed on the sides of the arbitrary triangle.

Wilson B **4:00P.M. – 5:00P.M.**

4:00–4:15

Constructing Fiber Polytopes: Recent Developments in Discrete Geometry

Joshua Withee

Western Michigan University

The paper "Fiber Polytopes" by Louis J. Billera and Bernd Sturmfels, published in 1992, presents significant results in polytope theory which open doors to many explorative opportunities. Their results bring together concepts in discrete geometry, combinatorics, algebraic geometry, and theory on polytopal subdivisions. Methods for constructing fiber polytopes provide ways to discover and develop combinatorial structures which contain information about the relationships between known convex polytopes. Fiber polytope theory has also lead to the furthering of our knowledge of triangulations and other types of polytopal subdivisions. This paper offers an introduction to fiber polytopes and related subjects, while presenting a fascinating and unexpected result by Billera and Sturmfels. The intent is to give undergraduates an accessible and inspiring glimpse of graduate-level geometry.

4:20–4:35

Graph Theory Representations and Computational Complexity of Sliding Block Ice Puzzles Inspired by Legend of Zelda

Megan Rodriguez

Hood College

Winning strategies and the complexity of single-player games, called puzzles, are a source of great interest in mathematical and computer science communities. Many popular video games employ these sorts of puzzles to provide challenges to players. We consider a specific instance of an underlying mathematical puzzle in a game. The Legend of Zelda video game series often includes puzzles involving sliding giant blocks around a grid covered in ice; the goal is to push a block until it stops on a pressure plate in the grid. We map two categories of these puzzles, one-block and n-block, onto digraphs and analyze winning strategies and solutions using graph theory. We then discuss and consider the algorithmic complexity of finding solutions and the computational complexity of these puzzles.

Wilson C **4:00P.M. – 5:00P.M.**

4:00–4:15

Open Problem in Fibonacci Numbers and Sequences

Leah Seader
California University of Pennsylvania

The Fibonacci Quarterly is a mathematical international peer review journal in which professionals and mathematicians publish research articles and pose challenging problems. These problems focus primarily on the Fibonacci numbers. The Fibonacci numbers are a sequence beginning with the numbers zero and one, and each new number is the sum of the two numbers preceding it. Fibonacci numbers have real world applications that can be applied to everyday life as operations are performed using the numbers of the sequence that causes different patterns to arise. My presentation will focus on an open problem proposed in The Fibonacci Quarterly. Specifically, I submitted an original solution to an open problem proposed in the February 2014 issue of the journal which was problem B-1144 proposed by D. M. Batinetu-Giurgiu, Matei Basarab National College, Bucharest, Romania and Neculai Stanciu, George Emil Palade School, Buzau, Romania. Not only did I solve the problem for the Lucas Numbers and Fibonacci Numbers sequences, but I also generalized a Fibonacci sequence that is true for all integers including zero. This problem was just recently selected for publication and was released in the February 2015 issue of the journal.

4:20–4:35

A Combinatorial Proof for a Fibonomial Coefficient Description

Jordan Weaver
Pepperdine University

The fibonomial coefficients $\binom{n}{k}_{\mathcal{F}}$, defined by $\binom{n}{k}_{\mathcal{F}} = \frac{F_{2n}!}{F_n!F_n!}$ where F_n is the well-known Fibonacci number, are an analogue of the well-known binomial coefficients. Similar to the binomial coefficients, they satisfy a recurrence given by $\binom{n}{k}_{\mathcal{F}} = F_{k-1}\binom{n-1}{k}_{\mathcal{F}} + F_{n-k+1}\binom{n-1}{k-1}_{\mathcal{F}}$. In 2010, Sagan and Savage gave a combinatorial interpretation of the fibonomial coefficients in terms of certain Fibonacci tilings of a k by $n-k$ rectangle. Their proof for this interpretation involved showing the set of tilings satisfied the fibonomial recurrence relation. In my talk, I will give a combinatorial proof for the Sagan and Savage interpretation of the fibonomial coefficients.

Delaware B **8:30A.M. – 11:45A.M.**

8:30–8:45

Mathematically Modeling Cancer Metastasis Through Mechanical Properties Detected by a Microfluidic Microcirculation Mimetic Device

Sruti Prathivadhi
Creighton University

Accounting for over 90% of cancer deaths, metastasis is a complex process by which cancer translocates to organs away from the primary tumour site. Unfortunately, existing cancer drugs do not target metastasis as our understanding of the field is limited. Thus, there is an urgent need for anti-metastasis therapy. In our project, we mathematically model the mechanical properties of metastasizing cancer cells during their circulation in blood vessels. Specifically, we consider the fluid dynamics of the microcirculation using a microfluidic platform which mimics capillary constrictions of the pulmonary and peripheral microcirculation. Using the Navier-Stokes equation, finite element analysis and COMSOL Multiphysics simulations, we extract the elastic and viscous properties of the cancer cells, subjected to various chemotherapeutic drugs. The mechanical properties enable us to assess, in a non-invasive manner, the pro- and anti-metastatic effects of these cancer drugs. Our work is a first step towards establishing cell mechanics as a readout to assist in effective anti-metastatic drug development.

8:50–9:05

Linear Analysis of a Straight Rod with Various Constitutive Relations

Victoria Kelley
James Madison University

Starting with a straight rod under tension, we are studying the perturbations in twist and bend using the Kirchhoff Rod Model. Additionally, we can include the effects of drag approximated by resisted force theory. We analyze this model under various constitutive relations. Finally, this model can inform us about the response of internal forces compared to external ones. This work has applications to the study of worm locomotion, bacterial flagella, and DNA.

9:10–9:25

A Staged Progression Epidemiological Model with Deceased-infectious Class

Kristen Sandberg
Marist College

A Lyapunov function argument establishing global stability results for the susceptible-exposed-infectious-removed (SEIR) model with demographic effects was first made by Korobeinikov. Since then, extensions have been made to this result, incorporating staged infectious classes, and recently, a deceased-infectious class. Here we will discuss some of these models, and describe our work in isolating similar Lyapunov function results for more complex systems.

9:30–9:45

The Dynamics of the Transmission of Malaria

Robert Doughty
Miami University

A system of differential equations modeling the dynamics of malaria transmission taking into account the lifestyle and life cycle of the mosquito and its interaction with the human population is analyzed. The model in question is revolutionary due to its focus only on the mosquitoes which are questing for human blood. We fix several variables within the system and vary several others to see what values cause the malaria to spread, remain constant, or leave the human population altogether. In particular we study the effect of an anti-parasitic medication, Ivermectin, on two threshold parameters which can determine the spread of malaria and additional information on the control of malaria is discovered.

9:50–10:05

China's Population and One-Child Policy

Shuyan Zhan
Randolph-Macon College

China is currently having a contracting age pyramid. This age structure is usually attributed to the One-Child Policy, which generally allows only one child per family in the country. Many are concerned about what the future population will be. Is it possible to predict the future population of China under the current policy? We built a matrix model simulating the growth of the population from the year of 2000 to 2010. The model has considerable accuracy in predicting the population of older age groups of year 2010, though we have uncovered evidence of bad data for younger age groups.

10:10–10:25

Interests in Conflict: Supporting Scientific Development and Ensuring Data Security

Samantha Parsons
Roanoke College

Is there a correlation between cancer incidences and geographical location within certain towns? What can we say about how criminal activity is related to income level? These questions are important to answer, but the data required to answer them contain confidential information that could be misused by a malicious person. Synthesizing data is a method that corporations and agencies can use to freely release important data while simultaneously honoring confidentiality agreements. The beauty of synthesizing data is that it preserves statistical information contained in the original data. This talk explains what synthetic data is and shows how to implement the method.

Delaware B **8:30A.M. – 11:45A.M.**

8:30–8:45

1, M, N - Antiautomorphisms of Directed Triple Systems

Lauren Snider
McNeese State University

We will consider a particular kind of combinatorial block design known as a directed triple system. A transitive triple, (a, b, c), is defined to be the set $\{(a, b), (b, c), (a, c)\}$ of ordered pairs. If D is a set of v points and β is a collection of transitive triples of pairwise distinct points in D satisfying the condition that any ordered pair of distinct points in D belongs to precisely one transitive triple of β, then the pair (D, β) is a directed triple system of order v, denoted by $DTS(v)$. An antiautomorphism of a $DTS(v)$ is a permutation on D which maps β to β^{-1}, where β^{-1} is the collection of the reverses of the transitive triples of β. Necessary conditions for the existence of a $DTS(v)$ that admits an antiautomorphism consisting of one fixed point and two cycles of lengths M and N, where $N > 2M$ and $M > 1$, have been shown by Neil Carnes and others. We will show sufficiency for the existence of a $DTS(v)$ admitting such an antiautomorphism for certain values of M and N.

8:50–9:05

Pattern Avoidance in Set Partitions

Emma Christensen
College of St. Benedict/St. John's University

A set partition avoids a pattern if no subdivision of that partition standardizes to the pattern. We find the sizes of several avoidance classes for patterns of partitions of $[4]$. We also characterize the restricted growth functions which are in a bijection with the set partitions of the avoidance classes of interest, and examine various statistics on these avoidance classes.

9:10–9:25

Rearrangement Groups of Fractals

Rebecca Claxton
Stockton University

Rearrangement groups are a generalization of Richard Thompson's groups that can be applied to investigate the symmetries of a wide class of fractals. In this talk, I will describe Thompson's group F as a rearrangement group and use rearrangement groups to discuss the symmetries of the Basilica Julia set and the Vicsek fractal.

9:30–9:45

Does Every Positive Integer have a Theoretical Friend of Finite Proximity?

Edna Jones
Rose-Hulman Institute of Technology

Two distinct positive integers are friends if they have the same abundancy index. In 2008, Jeffrey Ward formulated some conditions for 10 to have a friend. Ward also defined a theoretical friend of a given proximity of a positive integer and posed the following question: Does every positive integer have a theoretical friend of finite proximity? In this talk, we answer this question and discuss some related questions.

9:50–10:05

Affine Maps with Full Orbits in Modular Arithmetics

Gili Rusak

Siena College

In this talk, we consider affine maps in modular arithmetics. An affine map is of the form $P(x) = ax + b$, where a and b are integers. For a positive integer m, the map $P(x)$ is defined on $\mathbb{Z}_m$, the cyclic additive group of order m. The orbit of x is the smallest set, S, such that $x \in S$ and S is invariant under $P(x)$. Affine maps have applications in various disciplines including cryptography. We study the structure and size of the orbits of affine maps. We determine necessary and sufficient conditions on a and b under which every orbit of $P(x)$ coincides with $\mathbb{Z}_m$.

10:10–10:25

Surfaces in Hyperbolic Knot Complements

Aaron Calderon

University of Nebraska-Lincoln

Removing a knot from space yields a knot complement, and we say the complement is hyperbolic if there is a way to measure distance in the complement with a metric that is negatively curved. Surfaces in knot complements have long been used to understand the knots. We will discuss how those surfaces behave relative to the hyperbolic metric.

10:30–10:45

An Introduction to Klein Links and Their Relation to Torus Links

Steven Beres

Gonzaga University

Klein links form a classification of links which may be embedded across the surface of a Klein bottle. That is, a Klein link is a set of interlocking mathematical knots which may be drawn across the surface of a Klein bottle without intersection. This particular classification of links has not yet been well studied by the mathematical community. Initially, our interest in these links stemmed from the relation between Klein knots and torus knots. It is a fairly well-known fact that all Klein knots are torus knots. The initial goal of our research had been to explore the nature of this relationship through the use of elementary methods. These investigations led us to extend our inquiries to Klein links. After studying these links for some time, we came to discover that Klein links do not bear the same relation to torus links that Klein knots bear to torus knots. In other words, not all Klein links are torus links. In this presentation, we will briefly discuss the major results of our research on these links. The techniques that we used in our study of these links (such as linking number) were purposefully elementary, so this presentation does not require any background in topology or knot theory. Topics will range from basic construction of the links on the Klein bottle to specific sub-classifications of Klein links which are not torus links.

10:50–11:05

Topology: Generalizing Real Analysis

Nicole Trommelen
Sacred Heart University

In this talk we will enter the world of topology. We will look at what a topology is, and some of the different types of topologies. Then we will begin to look at how some of the things we have learned in Real Analysis relate to some different topological definitions. We will look at limits vs limit points and two different definitions of continuity, which we may later find out are not all that different after all. Finally we will use what we have learned to look at the proof of the Intermediate Value Theorem from a topological standpoint, and compare how this proof differs from the proof of the Intermediate Value Theorem in Real Analysis. The ultimate goal is to see how topology can be used to prove various theorems in Real Analysis and to see if proving some of theorems using topology is easier than proving the theorems in Real Analysis.

11:10–11:25

The Topology of Knight's Tours on Surfaces

Kara Teehan
Stockton University

A knight's tour is a sequence of moves that a knight can make on a chessboard where the knight visits each square exactly once, and makes its final move back to the square from which it started. The knights tour problem is an ancient puzzle studied by graph theorists and computer scientists. Generalizing the shape of the board from a rectangle to an orientable surface, specifically a cylinder or a torus, raises topological questions regarding the possible tours. I will give a characterization of the dimensions of cylinders and tori that admit particular homotopy classes of tours. More specifically, I will give a characterization of those cylinders and tori that admit nullhomotopic tours, and those that admit a tour that realizes one of the standard generators of the fundamental group of the surface. My arguments are primarily constructive, using patterns and induction arguments to prove the existence of tours on boards of allowable dimensions.

11:30–11:45

Drawing a Brick Wall, the Right Way

Gülce Sena Tuncer
Franklin & Marshall College

A savvy use of geometry allows non-artists to draw good-looking pictures in perspective. During a seminar on the Mathematics of Art, students learn a number of techniques that they can use to draw repeated objects (sidewalks, fence posts, and windows in a building). The goal of this talk is to briefly introduce one of these techniques and correctly draw a brick wall in perspective, as well as to compare examples that demonstrate different stages of learning in the course.

J. Sutherland Frame Lectures

2015	Noam Elkies	*G-Sharp, A-Flat, and the Euclidean Algorithm*
2014	Keith Devlin	*Fibonacci and the First Personal Computing Revolution*
2013	Gilbert Strang	*Matrices I Admire*
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*

MAA Lectures for Students

2015	Joseph Gallian	*Seventy-Five Years of MAA Mathematics Competitions*
2014	Jack Graver	*The Founding of Pi Mu Epsilon 100 Years Ago*
2013	Frank Morgan	*Optimal Pentagonal Tilings*
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 80658175170943878571660636856403766975289505440883277824000000000000*
2008	Laura Taalman	*Sudoku: Questions, Variations and Research*
2007	Francis Edward Su	*Splitting the Rent: Fairness Problems, Fixed Points, and Fragmented Polytopes*
2006	Richard Tapia	*Math at Top Speed: Exploring and Breaking Myths in Drag Racing Folklore*
2005	Annalisa Crannell & Marc Frantz	*Lights, Camera, Freeze!*
2004	Mario Martelli	*The Secret of Brunelleschi's Cupola*
2004	Mark Meerschaert	*Fractional Calculus with Applications*
2003	Arthur T. Benjamin	*The Art of Mental Calculation*
2003	Donna L. Beers	*What Drives Mathematics and Where is Mathematics Driving Innovation?*
2002	Colin Adams	*"Blown Away: What Knot to do When Sailing" by Sir Randolph "Skipper" Bacon III*
2002	M. Elisabeth Pate-Cornell	*Finding and Fixing Systems' Weaknesses: The Art and Science of Engineering Risk Analysis*
2001	Rhonda Hatcher	*Ranking College Football Teams*
2001	Ralph Keeney	*Building and Using Mathematical Models to Guide Decision Making*
2000	Michael O'Fallon	*Attributable Risk Estimation: A Tale of Mathematical/Statistical Modeling*
2000	Thomas Banchoff	*Interactive Geometry on the Internet*
1999	Edward G. Dunne	*Pianos and Continued Fractions*
1999	Dan Kalman	*A Square Pie for the Simpsons and Other Mathematical Diversions*
1998	Ross Honsberger	*Some Mathematical Morsels*
1998	Roger Howe	*Some New and Old Results in Euclidean Geometry*
1997	Aparna Higgins	*Demonic Graphs and Undergraduate Research*
1997	Edward Schaefer	*When is an Integer the Product of Two and Three Consecutive Integers?*
1996	Kenneth Ross	*The Mathematics of Card Shuffling*
1996	Richard Tapia	*Mathematics Education and National Concerns*
1995	David Bressoud	*Cauchy, Abel, Dirichlet and the Birth of Real Analysis*
1995	William Dunham	*Newton's (Original) Method, or, Though This Be Method, Yet There is Madness*
1994	Gail Nelson	*What is Really in the Cantor Set?*
1994	Brent Morris	*Magic Tricks, Card Shuffling and Dynamic Computer Memories*
1993	Richard Guy	*The Unity of Combinatorics*
1993	Joseph Gallian	*Touring a Torus*
1992	Peter Hilton	*Another Look at Fibonacci and Lucas Numbers*
1992	Caroline Mahoney	*Contemporary Problems in Graph Theory*
1991	Lester Lange	*Desirable Scientific Habits of Mind Learned from George Polya*

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CONGRATULATIONS TO THE 2014 ANDREE AWARD WINNER!

Sarah Ritchey

Youngstown State University

Points on a circle and integer distances

The Richard V. Andree Awards are given annually to the authors of the papers, written by undergraduate students, that have been judged by the officers and councilors of Pi Mu Epsilon to be the best that have appeared in the Pi Mu Epsilon Journal in the past year.

THE PME JOURNAL—CALL FOR STUDENT PAPERS

Mathfest is all about communication—so is the PME Journal. At the conference, listening is as important as talking. For a journal, readers are as important as authors. The Pi Mu Epsilon Journal readership and authorship is YOU. Send in your mathematical findings under a cover letter and feel the excitement of waiting for the referees' comments. The referees help you become better authors, but they are not, by any means, proof readers or error checkers, so submit only a polished, carefully crafted manuscript. But even if you find improvement unimaginable, most of the time rewriting is required before publication. The process is time consuming but the reward is great. Your paper in print in the PME Journal, now covered by JSTOR, will be accessible forever.

Congratulations to the MAA!

Pi Mu Epsilon wishes the Mathematical Association of America a hearty congratulations on its Centennial! PME and the MAA have a long history of working together to further mathematics and education. The MAA has provided generous support to PME over the years in many ways. For over half a century MAA has provided PME with space for its annual meeting at MathFest. PME looks forward to the next 100 years of marvelous cooperation between the societies as we promote research, education, mathematics, and community for generations to come.

Thank you
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Pi Mu Epsilon would like to express its appreciation to the American Mathematical Society, the American Statistical Association, the Committee for Undergraduate Research, the Society for Industrial and Applied Mathematics, Budapest Semesters in Mathematics, the SIGMAA-Environmental Mathematics and BioSIG-MAA for the sponsorship of the Awards for Outstanding Presentations. A special thanks is extended to Dover Publications and Princeton University Press for donating book prizes. It would additionally like to thank the National Security Agency Mathematical Sciences Program, Grant number H98230-15-1-0125, for its continued support of the student program by providing subsistence grants to Pi Mu Epsilon speakers.