Pi Mu Epsilon

Pi Mu Epsilon is a national mathematics honor society with 391 chapters throughout the nation. Established in 1914, Pi Mu Epsilon is a non-secret organization whose purpose is the promotion of scholarly activity in mathematics among students in academic institutions. It seeks to do this by electing members on an honorary basis according to their proficiency in mathematics and by engaging in activities designed to provide for the mathematical and scholarly development of its members. Pi Mu Epsilon regularly engages students in scholarly activity through its *Journal* which has published student and faculty articles since 1949. Pi Mu Epsilon encourages scholarly activity in its chapters with grants to support mathematics contests and regional meetings established by the chapters and through its Lectureship program that funds Councillors to visit chapters. Since 1952, Pi Mu Epsilon has been holding its annual National Meeting with sessions for student papers in conjunction with the summer meetings of the Mathematical Association of America (MAA).

MAA Student Chapters

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

Schedule of Student Activities

Unless otherwise noted, all events are held at the Hyatt Regency Columbus.

Wednesday, August 3

Time:	Event:	Location:
2:00 pm – 4:30 pm	CUSAC Meeting	Eisenman Columbus Convention Center
4:30 pm – 5:30 pm	MAA-PME Student Reception	Union D
5:30 pm – 6:15 pm	Math Jeopardy	Union Station Ballroom A Columbus Convention Center

Thursday, August 4

Time:	Event:	Location:
8:30 am – 11:30 am	PME Council Meeting	Ohio Center B Columbus Convention Center
8:30 am – 10:25 am	MAA Session #1	Madison
	MAA Session #2	Fayette
	MAA Session #3	Clark
	MAA Session #4	Champaign
1:00 pm – 1:50 pm	MAA Chan Stanek Lecture for Students	Regency Ballroom
2:00 pm – 3:55 pm	MAA Session #5	Madison
	MAA Session #6	Fayette
	MAA Session #7	Clark
	MAA Session #8	Champaign
	PME Session #1	Knox
	PME Session #2	Marion
	PME Session #3	Morrow
4:00 pm – 6:15 pm	MAA Session #9	Madison
	MAA Session #10	Fayette
	MAA Session #11	Clark
	MAA Session #12	Champaign
	PME Session #4	Knox
	PME Session #5	Marion
	PME Session #6	Morrow
4:10 pm – 5:25 pm	Speed Interviewing Marathon for Students	McKinley

Friday, August 5

Time:	**Event:**	**Location:**
7:00 am – 8:00 am	PME Advisors Breakfast Meeting	*tba*
8:30 am – 11:45 am	MAA Session #13	Madison
	MAA Session #14	Fayette
	MAA Session #15	Clark
	MAA Session #16	Champaign
	PME Session #7	Knox
	PME Session #8	Marion
	PME Session #9	Morrow
1:00 pm – 1:50 pm	MAA Activity: Games Mathematicians Play	Hayes
2:00 pm – 3:15 pm	PME Session #10	Knox
	PME Session #11	Marion
2:35 pm – 3:55 pm	Non-Academic Career Paths Panel	McKinley
3:30 pm – 5:00 pm	Estimathon!	Taft A
6:00 pm – 7:45 pm	Pi Mu Epsilon Banquet	Franklin
8:00 pm – 8:50 pm	Pi Mu Epsilon J. Sutherland Frame Lecture	Regency Ballroom
9:00 pm – 10:00 pm	MAA Ice Cream Social and Undergraduate Awards Ceremony	McKinley

Saturday, August 6

Time:	**Event:**	**Location:**
9:00 am – 10:15 am	MAA Modeling (MCM) Winners	McKinley
1:00 pm – 2:15 pm	Student Problem Solving Competition	Franklin A
1:00 pm – 5:00 pm	Great Talks for a General Audience	Madison

Jean B. Chan and Peter Stanek Lecture for Students

ZOMBIES & CALCULUS: A SURVIVAL GUIDE

Colin Adams
Williams College

If you are reading this, then you have managed to survive the zombie apocalypse so far. Congratulations! But as the world sinks further into ruin, what additional strategies can you apply to endure the onslaught? Learn how calculus can help you to defeat the zombie hordes. The lecture room will be will be certified a safe haven for the duration of the talk.

MAA Undergraduate Student Activity Session

GAMES MATHEMATICIANS PLAY

Christopher Swanson
Ashland University

A combinatorial game is a game between two opposing players who make alternate moves from some starting position with each player having a finite number of moves available and knowing all possible moves of both players. Furthermore, moves are not determined by chance and the game lasts at most a certain number of turns, with the result being a win for one player or a draw. Tic-Tac-Toe and Chess are two well-known combinatorial games. In analyzing combinatorial games, the basic question is who should win if two expert players play the game — the player who goes first, the player who goes second, or should the game end in a draw? In this student activity, audience members will play a number of combinatorial games and try to determine the answer to this basic question.

J. Sutherland Frame Lecture

COMBINATORICS — THE MATHEMATICS THAT COUNTS

Robin Wilson
Open University

How many Sudoku puzzles are there? Are there 33 Londoners with the same number of hairs on their head? Can a knight visit all the squares of a chessboard just once? And can we tile a floor with squares and regular hexagons? These are all problems in combinatorics, the branch of mathematics concerned with selecting, arranging, counting, and listing things. In this talk I shall illustrate the nature and uses of combinatorics by means of a number of entertaining problems.

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
Jimmie Adriazola	New Jersey Institute of Technology	6
Corey S. Afton	William & Mary	5
William S. Anderson	Indiana University South Bend	4
Aricca Bannerman	Ferris State University	2
Jordan V Barrett	Syracuse University	10
Berlinda Rosa Batista	Bridgewater State University	11
Hayley Bertrand	St. Norbert College	9
Ryan Bianconi	Ithaca College	3
Subekshya Bidari	Trinity College	8
Scott A. Brewer	Creighton University	3
Chance Browning	St. Norbert College	4
Sara Brumbaugh	Marshall University	1
Monica Busser	Youngstown State University	7
Recep Celebi	Lafayette College	6
Rebecca M. Cooper	University of Mount Union	9
Jayshawn Cooper	Morgan State University	10
Brian D. Darrow, Jr.	Southern Connecticut State University	2
Niusha Davachi	University of Texas at Arlington	3
Samuel Edwards	Gettysburg College	7
Mitchell J. Eithun	Ripon College	11
James Emington	Ferris State University	2
Justin Conor Flaherty	Cleveland State University	6
Adam Y. Fong	Trinity College	9
Joseph C. Fuess	Mercy College	4
Michael D. Gableman	Ripon College	2
Natalie Halavick	Youngstown State University	1
Brad T. Hall	Wake Forest University (Graduate)/Southeastern Louisiana University (Undergrad)	7
Jordan G Hardy	University of Idaho	7
Joshua Haug	Pepperdine University	6
Nicholas Heiner	Hendrix College	9
Rebecca B Hoehne	Saint Mary’s College	8
Emily Hoopes	Youngstown State University	7
Peter L. Jakes	Elon University	7
Jiyi Jiang	Hope College	8
David B. Jones	Marshall University	1
Marjorie T. Jones	Pepperdine University	8

Pi Mu Epsilon Speakers (Continued)

Name	School	PME Session
Victoria M. Kelley	James Madison University	8
Olivier Kwizera	Hendrix College	5
Michael J. Leazer	Carthage College	9
Aixin Li	Denison University	6
Tong Luo	Wake Forest University	1
Crystal Mackey	Youngstown State University	1
Alyssa Malzone	Lewis University	2
Alexander T. Mathers	University of Alabama	9
Grace McCourt	Ashland University	5
Theodore Mishura	Stockton University	5
Shriya Nagpal	Trinity College	5
Ahmad I Nazeri	Randolph-Macon College	10
Sabin K. Pradhan	St. Peter's University	5
Sam Rakocy	Youngstown State University	1
Alena Schwartsman	Cleveland State University	6
Kelsey Scott	Grand Valley State University	7
Kevin J. Shuman	Edinboro University of Pennsylvania	9
Travis Spillum	St. John's University	7
Ben Stortenbecker	University of South Florida	11
Kurt R. Sweat	University of Nevada, Las Vegas	3
Daniel J. Tjie	Ithaca College	4
Sang Truong	University of California, Irvine	9
Gabbie Van Scoy	Youngstown State University	8
Allison VanderStoep	Hope College	8
Daniel Voce	St. John's University	8
Jack Wagner	Armstrong State University	2
Zack While	Youngstown State University	8
Jenna Wise	Youngstown State University	8
Lingxi Wu	Indiana University - Purdue University Fort Wayne	9
Yanqi Xu	Kenyon College	4
Vasily Zadorozhnyy	Grand Valley State University	7
Tiancheng Zheng	Denison University	9
Yulin Zhu	Gettysburg College	7

MAA Student Speakers

Name	School	MAA Session
Amanda Akin	Lee University	3
Brady Ali Medina	Universidad Nacional De San Agustin	5
Stanislav Atanasov	Yale University	9
Alexander Audet	Southern Connecticut State University	7
Rachel Barnett	Rutgers University	16
Laura Beitler	Augustana College	10
Angel Beltran	Dixie State Univeristy	15
Matt Bradley	Wentworth Institute of Technology	10
Nicole Buczkowski	Jacksonville University	11
Kaitlyn Burk	Lee University	8
Joshua Bussiere	McDaniel College	4
Zhaodong Cai	University of Illinois at Urbana-Champaign	11
Alois Cerbu	Yale University	6
Matt Chen	Goshen College	5
Aaron Chen	Cornell University	15
Stefano Chiaradonna	Benedictine University	15
Jocelyn Correa	Texas Women's University	13
David Cox	Texas A&M University	11
Victoria Davis	University of North Alabama	3
Leo Di Giosia	Lewis and Clark College	8
Thierno Diallo	City Tech, CUNY	15
Morgan Engle	Southwestern University	14
Kevin Garcia	Manhattan College	13
Jonathan Gerhard	James Madison University	2
Hannah Grant	Texas Women's University	1
Jay Habib	Williams College	8
Daniel Harper	North Carolina State University	7
Daniel Hartman	University of West Georgia	12
Madison Hays	Pepperdine University	16
Daniel Houston	Eastern Kentucky University	13
Katharine Howard	Benedictine University	15
Garrison Iams	Klamath Community College	2
Austen James	Yale University	11
Yujie Jiang	Wake Forest University	10
Cole Johnson	Hood College	6
Jon Kaasa	Goshen College	11
Hsien-Te Kao	California State Polytechnic University, Pomona	14
Lara Kassab	Lebanese American University	4
Lea Kenigsberg	Stony Brook University	8

MAA Student Speakers (Continued)

Name	School	MAA Session
Tiffany Klink	Klamath Community College	3
Matthew Knight	Lewis University	3
Kiran Kumar	Williams College	16
Jade Larriva-Latt	Wellesley College	1
Aubrey Laskowski	University of Illinois at Urbana-Champaign	11
Brandon Lee	University of Michigan - Dearborn	13
Eric Lewis	City Tech, CUNY	4
Fengyi Li	Texas A&M University	13
Stephen Liddle	George Mason University	3
Nicholas Lindell	University of Georgia	9
Erin Lipman	Haverford College	16
Stephanie Loewen	Grand Valley State University	12
Chris Magyar	University of Wisconsin - Eau Claire	2
William McDermott	Virginia Tech	5
Konstantin McKenna	Boston University	4
Dylan McKnight	Saginaw Valley State University	10
Eise McMahon	Cambridge University	9
Nathan Mehlhop	Texas A&M University	13
William Milligan	Emory University	14
Rose Mintzer-Sweeney	Yale University	6
Nelson Moll	University of California Irvine	12
Michael Moore	Columbia University	16
Jihad Nasser	Michigan State University	4
Quinton Neville	St. Olaf College	15
DeWein Pelle	University of the Virgin Islands	14
Dylanger Pittman	Williams College	8
Tanya Plascencia	University of Central Oklahoma	12
Sanjay Raman	Lakeside School Seattle	6
Miriam Ramirez	California State University, Northridge	5
Taylor Rink	Hope College	14
Elizabeth Rodriguez	Benedictine University	14
Samuel Rogers	Saint John's Preparatory School	1
Becca Rousseau	Taylor University	13
Madison Rowe	Arkansas State University	13
Slade Sanderson	Pepperdine University	14
Marko Saric	Benedictine University	4
Cory Saunders	Haverford College	16
Blake Schildhauer	McDaniel College	10
Rachel Schueller	University of Miami	14

MAA Student Speakers (Continued)

Name	School	MAA Session
Thomas Schuler	Nebraska Wesleyan University	9
Leah Seader	California University of Pennsylvania	1
Farida Shahata	American University in Cairo	6
Cheng Shi	James T. Townsend	7
Rachel Shore	Agnes Scott College	1
Callie Sleep	South Dakota State University	12
Samantha Smith	McDaniel College	10
Shruthi Sridhar	Cornell University	16
William Vickery	Stony Brook University	16
Brandon Voigt	College of St. Benedict/St. John's University	9
Broderick Wagerson	University of Michigan - Dearborn	7
MacKenna Waggener	Pepperdine University	16
Sirui Wang	Cornell University	9
Noah Watson	James Madison University	7
Nicholas Wawrykow	Yale University	2
Scott Weady	Yale University	2
Anthony Webb	Northern Michigan University	12
David Wendl	University of Michigan - Dearborn	15
Danial Wentland	University of Wisconsin - Stevens Point	5
Caryn Willis	Indiana Wesleyan University	14
Alexander Wilson	Michigan State University	5
Rose Winter	St. Catherine University	9
Lucy Yang	University of Minnesota	16
Kyle Zeberlein	Augustana College	7
Meryn Zeigler	The University of Texas	6
Zijing Zhang	Kent State University	13
Weitao Zhu	Williams College	8

Knox **2:00P.M. – 3:55P.M.**

2:00–2:15

Evaluating Patrol Zones using Discrete Event Simulation

Sara Brumbaugh
Marshall University

The Huntington, WV Police Department patrol zones have, due to changes in crime distribution and the makeup of the department, become ineffective over the last 14 years. In this talk, we will explain how we derived new zone plans and discuss a method we used to evaluate them called Discrete Event Simulation. The effectiveness of the maps were evaluated by writing a program to mimic the overall patrol patterns of an officer, and output a workload distribution and response time by which we can judge them. This project was part of the PIC Math program, which is sponsored by the MAA, NSF, and SIAM.

2:20–2:35

Patrol Zone Realignment for Huntington Police Department by Gradient Descent

David B. Jones
Marshall University

Patrol zones for the Huntington Police Department have, due to changes in crime distribution and the makeup of the department, become ineffective over the last 14 years. In this talk, we will discuss one solution for this problem. Taking into account feedback and criticisms on the current zoning scheme from officers, a fitness function was created to evaluate the relative effectiveness of existing zoning schemes. Intuition-driven maps were created and then optimized using a method of gradient descent in conjunction with the fitness function. This project was part of the PIC Math program, which is sponsored by the MAA, NSF, and SIAM.

2:40–2:55

Historic Crime Analysis: Examining and Predicting Crime in Youngstown, Ohio

Natalie Halavick
Youngstown State University

Since 2009, the Youngstown Neighborhood Development Corporation (YNDC) has avidly worked to restore houses and neighborhoods in Youngstown, Ohio. This paper first employs Census and crime statistics in Youngstown to illustrate and predict future crime spread throughout the city, using methods including GIS and regression analysis, respectively. Results exhibited a foreseen movement of total crime away from the North and East parts of the city, creating an increase in the West and South sides. The second section looks at YNDC's current intervention in Census tracts within the city, comparing them to control groups to determine its immediate effects on crime rates in such areas. An ANOVA test determined that crime over a two-year period was not affected by YNDC intervention in a statistically significant way, however previous studies suggest that more time is necessary to field positive results. The YNDC will consider this study‘s outcomes when planning future improvement projects.

3:00–3:15

Numerical Results for the IVP to the Burgers Equation with External Forces

Crystal Mackey

Youngstown State University

In this project, we use Burgers equation to study traffic flow, including shock and rarefaction waves, where traffic density, traffic flow and velocity are the main variables expressed as functions of position and time. The derivation of the conservation law from physical principles can be reduced to the Burgers equation. The initial value problem (IVP) of Burgers equation is a partial differential equation with an initial condition. Our objective is to numerically approximate solutions to the IVP for Burgers equation with external forces. After deriving the Lax-Wendroff method and modifying it to improve numerical approximations, adaptations are made to include an external force term. External forces may help to capture physical traffic interpretations such as traffic lights, driver interactions, multiple lanes or on and off ramps on a highway. Our goal is to approximate solutions to the IVP for Burgers equation with external forces and compare our numerical simulations to real data. In this talk, we compare our numerical simulations to real data and present the methods used.

3:20–3:35

Using Individual Based Modeling to Determine the Fastest Driving Route

Sam Rakocy

Youngstown State University

When driving through high traffic areas, it can be very unpredictable what one may run into. A road under construction, a wreck, unforeseen traffic jams, or many other possibilities can back up traffic. Current technology, such as GPS device, cell phones, the Google app, make it possible for drivers to avoid all of these issues in order to get to their destination as soon as possible by looking at real time traffic data and rerouting drivers. Some of that technology studies users daily trips, destinations and habits to be able to predict when and where the user is headed and offer optima routes to facilitate travel. This prevents drivers from encountering backed up traffic in their original route by offering the best possible alternative. This talk presents a possible solution to this problem using mathematical and computational self-learning adaptive algorithms. These algorithms will take a step in helping understand how it is possible for these algorithms to exist.

3:40–3:55

Traffic Flow Modeling for Multi-Lane Situations with Heterogeneous Driver Behavior

Tong Luo

Wake Forest University

Researchers from many universities have already done research on traffic flow in single-lane situations. In this talk, we will develop a model for traffic flow that incorporates lane changing. We will use a microscopic car-following model based on the Improved Intelligent Driver Model and Gipps' Model. In addition, we will also consider heterogeneous driver behavior such as aggressiveness, attentiveness, and courtesy. Additionally, we will compare our theories with simulations and empirical data.

Marion **2:00P.M. – 3:55P.M.**

2:00–2:15

Pythagoras to Secor: Improving the Miracle Temperament I

Arrica Bannerman
Ferris State University

A musical temperament is a system of tuning with evenly spaced notes. Every musical note is actually the result of overlaying many different pitches called overtones. In order for music to sound harmonious, the overtones must line up. However, overtones are not evenly spaced, so any temperament will deviate from some overtones. Since the days of Pythagoras, mathematicians and musicians have struggled with the question: "What temperament best approximates the overtone sequence?" In 1974, the composer George Secor discovered a temperament that made great progress on this question. His "Miracle" temperament was received by the music composition community as the best approximation for the first eleven overtones. This talk explains how linear programming techniques can be applied to the study of the temperament question. The main result presented is a new temperament that gives a better approximation of the overtone sequence than the Miracle temperament.

2:20–2:35

Pythagoras to Secor: Improving the Miracle Temperament Part II

James Emington
Ferris State University

A musical temperament is a system of tuning with evenly spaced notes. Every musical note is actually the result of overlaying many different pitches called overtones. In order for music to sound harmonious, the overtones must line up. However, overtones are not evenly spaced, so any temperament will deviate from some overtones. Since the days of Pythagoras, mathematicians and musicians have struggled with the question: "What temperament best approximates the overtone sequence?" In 1974, the composer George Secor discovered a temperament that made great progress on this question. His Miracle temperament was received by the music composition community as the best approximation for the first eleven overtones. This talk focuses on a new algorithm used to search the (very large) space of possible temperaments. The main result is a full categorization all Miracle-like temperaments, extending Secor's work to arbitrarily large instruments.

2:40–2:55

Matrix Group Representation of Music Compositions

Jack Wagner
Armstrong State University

The connection between mathematics and music has been apparent and studied as far back as Ancient Greece with plenty of overlap between great mathematicians and great musicians. In this talk we will generate a representation of the tools of musical composition as a transformation group. Several group theoretic properties will be illustrated in the context of musical thematic development. It will be shown that element order, cyclic subgroups, orbits, and eigenspaces each have a meaningful interpretation in the field of musical composition.

3:00–3:15

Bertrand's Ballot Theorem with Three Candidates

Michael D. Gableman
Ripon College

Elections play a prominent role in society; they can be used to determine anything from the restaurant choice of a group of friends to a country's next leader. Since elections are used so often to make decisions, it is not surprising that mathematicians have studied the structure of election processes. One theorem that provides some information on the structure of an election is Bertrand's Ballot Theorem, which is a result of combinatorics with applications in social choice theory. Bertrand's Ballot Theorem identifies the probability that the winner of a two-candidate election was always ahead of or tied with the other candidate as ballots were tallied. Bertrand's Ballot Theorem is limited to dealing with two candidate elections, and this talk will discuss how to expand the theorem to apply to three-candidate elections.

3:20–3:35

On Mathematics Course Placement and Overall Academic Success in College: A Longitudinal Cohort Study at a Four-Year Public University $n = 1,237$

Brian D. Darrow, Jr.
Southern Connecticut State University

Understanding what enables students to thrive upon entering college is crucial in supporting their future success. It is essential that incoming students be in the best possible position to succeed starting in their first semester in college. When students attend Southern Connecticut State University (SCSU) as freshmen, like most 4-year public institutions in the United States, they are enrolled in a required mathematics course. Students are placed into these courses according to their score on the mathematics section of the SAT (unless otherwise challenged). Our research, conducted in an Honor's Thesis in the SCSU Mathematics Department, aims to investigate how mathematics placement and performance in collegiate math courses impacts student success. Specifically, the study compares the efficacy of mathematics course placement based on the math section score of the SAT with the efficacy of math course placement based on pre-college information. Our research also investigates how students performance in their first math course influences their cumulative GPA, persistence, retention, and graduation. Results gleaned from multivariate statistical analyses conducted on real, SCSU longitudinal student cohort data from the incoming class of 2009 ($n = 1,237$) provide a summary of the relationship between success in mathematics and overall success in college. The results of the study have the potential to influence admission procedures, modify mathematics course placement policies, and inform educational perspectives involving mathematical competency and overall academic success at SCSU.

3:40–3:55

Comparing Assessment Techniques in Calculus II

Alyssa Malzone
Lewis University

As the world of education evolves, teachers are doing all they can to provide the best for their students. As a result of this, educators are exploring different alternate assessments in their classrooms. In this talk, we will explore one such alternate assessment method known as "mastery-based testing" (sometimes called "specifications grading"). We will present the preliminary results of a two-year study in which we compared mastery-based assessment with traditional assessment in Calculus II courses. In particular, we were curious to see if there was any difference in student achievement or student satisfaction between traditional testing and this new mastery-based testing. To help us in our research, we conducted statistical analysis of surveys from students. Half of the classes followed the traditional testing, while the other implemented mastery-based testing. In the surveys, we asked questions regarding anxiety and study methods. Students were asked to rate this on the Likert scale. We also looked into student scores on an end of the year review assessment.

Morrow **2:00P.M. – 3:55P.M.**

2:00–2:15

No Talk

Speaker Canceled

2:20–2:35

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

Scott A Brewer

Creighton University

Given the monomial $P^{m_1,m_2}(z_1,z_2) = z_1^{m_1} z_2^{m_2}$, Feynman's operational calculus is used to compute the disentangled operator $P^{m_1,m_2}_{\lambda_1,\lambda_2}(A,B)$ using time-ordering "directions" given by the Borel probability measures λ_1 and λ_2 on $[0,1]$, where $A, B \in \mathcal{L}(X)$ are noncommuting linear operators on the Banach space X. Select sequences $\{\eta_{1,k}\}_{k=1}^{\infty}$ and $\{\eta_{2,k}\}_{k=1}^{\infty}$ of purely discrete finitely supported probability measures on $[0,1]$ which converge weakly to λ_1 and λ_2, respectively. We wish to prove that $P^{m_1,m_2}_{\eta_{1,k},\eta_{2,k}}(A,B) \to P^{m_1,m_2}_{\lambda_1,\lambda_2}(A,B)$ in norm on $\mathcal{L}(X)$. Given a complex-valued function $f(z_1,z_2)$ which is analytic on the open polydisk with radii $\|A\|$ and $\|B\|$ and continuous on its boundary, we can then show, using the Taylor series for f, that $f_{\eta_{1,k},\eta_{2,k}}(A,B) \to f_{\lambda_1,\lambda_2}(A,B)$ in norm on $\mathcal{L}(X)$.

Progress has been made with regard to the assertion concerning monomials using $\lambda_1 = \lambda_2 = \ell$, where ℓ is Lebesgue measure on $[0,1]$. This talk will discuss this progress and point out the direction of the future research. So far, we have finished two cases and are working towards finishing the third case. By proving these assertions in a direct fashion, it is expected that new features of the operational calculus will be exhibited and that such features will be able to be exploited to further investigate the operational calculus.

2:40–2:55

Applications of the $\mathscr{L}_2$ transform to Dawson's Integral

Ryan Bianconi

Ithaca College

Provided are the definitions for the $\mathscr{L}_2$ transform and Dawson's Integral, respectively:

$$\mathscr{L}_2\{f(x);y\} = \int_0^{\infty} x e^{-x^2y^2} f(x)dx,$$

$$\text{daw}(x) = \int_0^{x} e^{y^2-x^2} dy.$$

We introduce a differential operator and a convolution product for the transform. Using the transform and its properties, we obtain results about Dawson's integral. Our operational techniques simplify the complicated calculations.

3:00–3:15

Strict Definition and Some Properties of Elementary Functions

Kurt R. Sweat

University of Nevada, Las Vegas

In many contemporary calculus and other analysis books almost all of the problems involve elementary functions. However, to the best of our knowledge, books do not give readers a strict definition or properties of an elementary function. In our talk, we give the strict definition and some properties of an elementary function which show how rich and useful these functions are. We also discuss how more properties, as well as formulas and shortcuts may be found to aid in solving most complicated calculus and other analysis problems. This definition for an elementary function and its consequent theorems could be a useful aid for instructors and readers of mathematical books. In addition, in our talk, we explain how problems which involve functions which are not elementary, such as some piecewise functions, may make use of these properties and formulas.

3:20–3:35

Standard and Non-Standard Lagranigans

Niusha Davachi

University of Texas at Arlington

A concept of non-standard Lagrangians is introduced and general conditions for the existence of such Lagrangians are presented. The conditions are used to determine classes of ODE's that can be derived from non-standard Lagrangians. The obtained results are used to obtain non-standard Lagrangians for several dynamical systems of physical interest.

3:40–3:55

No Talk

Speaker Canceled

Knox **4:00P.M. – 6:15P.M.**

4:00–4:15

Euler's Totient Gunction: Prime Stairway Lower Bounding

William S. Anderson
Indiana University South Bend

Euler's totient function counts the positive integers up to a given integer n that are relatively prime to n. In this presentation we attempt to provide evidence for the following conjecture. For each positive integer k, the first integer m such that $\phi(m) \geq k$ is prime. In a recent paper by Adrian Dudek, it was shown that there is a prime between n^3 and $(n+1)^3$ for all $n \geq \exp(\exp(33.217)$. We attempt to slightly refine this result in order to show that this result helps in dealing with products of three or more primes. In the case of the product of two primes we show that if one assumes Oppermann's conjecture it implies the conjecture is true for 2 primes.

4:20–4:35

Explorations of Finger Games

Daniel J. Tjie
Ithaca College

Finger Games, a topic in number theory, study certain $1-1$ operations on sequences of 0's and 1's of length $2f$ - viewing the left and right half as f fingers of adjacent hands interpreted using Gray Code. An up finger represents a 1 and a down finger represents a 0. Finger Games involve the operation of counting in Gray Code by an even number C, alternating hands. As the operations are $1-1$, they divide the sequences into orbits. A position of an orbit is called "even" if it is has an even number of 1's. We restricted our attention to the even parts of orbits as several previous results suggest these are easier to determine. In even parts of orbits, either both hands are even and repeatedly and alternately increase by C (called an upsweep) until an overflow occurs, or both hands are odd and repeatedly and alternately decrease by C (called a downsweep) until an underflow occurs. A multistep, which is the result of an upsweep, overflow, downsweep, and underflow typically has one hand go down by d or up by u where $d = 2f \bmod C$ and $u = C - d$ and the other hand does the same on the bottom and then adds 2 when read backwards. Using this, one can view hands as having a bottom with the same number of bits as C and a top with the rest of the bits. In my research I studied the even parts of orbits for counting by $C = 6$ and 10. A major part of my work was determining the interactions between tops and bottoms of hands.

4:40–4:55

Exploring the Abundancy Outlaw

Yanqi Xu
Kenyon College

The abundancy index of a positive integer n is defined to be the rational number $\sigma(n)/n$ where $\sigma(n) = \sum_{d|n} d$ is the sum of the divisors of n, and $I : \mathbb{N} \to \mathbb{Q} \cap (1, \infty)$ is the function defined by $I(n) = \sigma(n)/n$. Erdos showed that I is not onto, and if $n > 1$ fails to fall in the range of I, then n is called an "abundancy outlaw." In this paper we examine rational numbers of the form $(\sigma(n) + t)/n$, where t is a positive integer, to produce and characterize new classes of outlaws.

5:00–5:15

A Primitive Prime Test

Joseph C. Fuess
Mercy College

In this paper, we explore a universal feature of the odd, composite numbers which creates a non-trivial distinction between this set and the set of prime numbers, resulting in an effective test for primality. We begin with a brief summary of this long-studied topic, and following the summary we introduce basic terminology, definitions, and primitive observations which motivate the dialogue toward its major proposition which embodies an original prime-number-test. Following the exhibition of the major proposition, we consider additional properties which serve to reduce the effective time- complexity in a practical computation scenario.

5:20–5:35

Generalizations of the Josephus Problem

Chance Browning
St. Norbert College

In the classic Josephus Problem, you start with m people in a circle and go around, eliminating every kth person until only one person remains. Where should someone be in the original circle in order to be the last one remaining? We will answer this question and discuss variations of the problem.

Marion **4:00P.M. – 6:15P.M.**

4:00–4:15

Characterizing Cycle Partitions in 2-Row Bulgarian Solitaire

Sabin K. Pradhan
Saint Peter's University

This paper studies cyclic partitions under the operation 2-row Bulgarian solitaire. We develop tools such as block notation to make characterizing cyclic partitions easier. Using these blocks, we see that cyclic partition under 2-row Bulgarian solitaire have independently cycling diagonals satisfying one of four conditions. We conclude with an enumeration results that allow us to calculate the number of cyclic partitions for a given integer n.

4:20–4:35

The Dishonest Salesperson Problem

Grace McCourt
Ashland University

A salespersons office is located on a vertex v of a connected graph G with n vertices. There are $n - 1$ customers located at each of the other vertices of the graph. The salesperson must make a driving trip whereby he or she leaves the office, visits each customer exactly once and then returns to the office. Because a profit is made on the mileage allowance, the salesperson wants to drive as far as possible during the trip, with each edge of the graph representing one mile. What is the maximum possible distance he or she can travel on such a trip, and how many different such trips are there? Problem 1654 from *Mathematics Magazine* answered this question if the graph is a path graph. In this talk, I will present solutions for other types of graphs.

4:40–4:55

Generating Random Instances Of Algebraic Data Types in Haskell

Olivier Kwizera
Hendrix College

Generating random combinatorial structures such as lists, trees, permutations and graphs is an important problem and can be useful when testing properties of functions or programs on random input. However, being able to efficiently generate random combinatorial objects of a suitable size is challenging in practice. Duchon et al. draw ideas from statistical mechanics to show how Boltzmann distributions can be used to generate random instances of a combinatorial class in linear time proportional to the size of the objects being generated. A Boltzmann sampler for a combinatorial class uses the generating function of that class to ensure that objects of the same size are drawn with uniform probabilities. My talk will explain how we apply the idea of Boltzmann samplers to generate uniform random instances (of an approximate size) of algebraic data types in the Haskell programming language by extracting appropriate generating functions from the generic definition of the data type.

5:00–5:15

Self-Avoiding Walks on a Rectangular Grid

Theodore Mishura
Stockton University

Certain varieties of self-avoiding walks connecting the bottom left lattice point to the top right lattice point of a rectangular grid are counted using a combination of recursive functions and traditional counting methods. Among these varieties of walks discussed are walks of minimum length, walks of minimum length $+2$, walks that move in exactly three of the four cardinal directions, and walks contained on a $2 \times N$ grid.

5:20–5:35

On the Domination Number of Generalized Hierarchical Products

Shriya Nagpal
Trinity College

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 $\gamma(G)$. In 2008, Barrière et al. introduced the hierarchical product of graphs which is a generalization of the well-known Cartesian product of graphs. Recently, Anderson et al. considered the hierarchical product of a path P_n with any graph H, and they gave a lower bound for the domination number of the product in terms of $\gamma(P_n)$ and $\gamma(H)$. We generalize some of their results by providing a lower bound for the domination number of the hierarchical product of any two graphs G and H.

5:40–5:55

Routing Permutations on n-dimensional Hypercubes

Corey S. Afton
College of William and Mary

We define the routing number $rt(G)$ of a connected graph G: Let T be a set of permutations such that each $\sigma \in T$ is of the form $\sigma = \tau_1 \ldots \tau_p$, where $\tau_i = (r, s)$ is a transposition that represents swapping endpoints of the edge $rs \in E(G)$, given that $\tau_i\tau_j = \tau_j\tau_i$ for any $i, j \in \mathbb{N}$. Then, $rt(G)$ is the least integer k such that any permutation on vertices can be reduced to the product $\sigma_1 \ldots \sigma_k$. In addition to illustrating the conception of $rt(G)$ for simple structures such as paths, I will discuss recent work on improving the bounds of $rt(G)$ for n-dimensional hypercubes through theoretical and high performance computational methods.

Morrow **4:00P.M. – 6:15P.M.**

4:00–4:15

Fokker-Planck and Langevin Approach to Brownian Motion and Langevin Analysis of Optically Trapped Cilium

Justin Conor Flaherty
Cleveland State University

Small particles in a fluid ('tracer particles') undergo a randomized form of movement called Free Brownian motion. This movement is caused by molecules within the fluid colliding with the 'tracer', causing the particle to move freely in any direction. Rather than describe the particle position $x(t)$, It is more convenient to characterize the particle's motion in terms of its mean squared displacement, or MSD, which is a single parameter model of the motion. A free particle can also be confined in an optical laser trap, which changes the behavior of the MSD. There are multiple approaches to deriving the MSD formulas in both the free and confined cases, which we will discuss in this paper. We will also apply an optical laser trap to a cantilever structure instead of a tracer particle and obtain its MSD.

4:20–4:35

Curiosities of the Lorenz System

Alena Schwartsman
Cleveland State University

I will define the basic properties of dynamical systems and briefly discuss the historical background of Edward Lorenz. I will also explore, in depth, the parameters and properties of the Lorenz system. I will use numerical and graphical tools to demonstrate the behavior of the Lorenz attractor.

4:40–4:55

Playing the Monty Hall Game on a Quantum Circuit

Aixin Li
Denison University

In the classic Monty Hall game there are 3 doors and behind these doors two goats and a car are distributed. The player picks a door, hoping for the car. Monty Hall, the game show host, examines the other doors and always opens one of them with a goat (if both doors have goats behind them; he'll randomly pick one to open). After that, the player has a chance to decide whether he is going to stay or switch to the other door. After this, Monty will open all the doors and player wins if he/she got the door with a car. In this standard scheme, the player maximizes the chance of winning at 2/3 by choosing the fixed strategy of always switching after the first reveal. Information and uncertainty are technical terms that describe any process that can be used to analyze the selection of one or more objects from a set of objects. Suppose we have a device that can produce 3 symbols, A, B, or C. As we wait for the next symbol, we are uncertain as to which symbol it will produce. Once a symbol appears and we see it, out uncertainty decreases; that is, we have received some information. In this case, information is a decrease in uncertainty. This notion of information is formalized and deepened in the theory of Shannon information. We show how information can be used to analyze both the classical and quantum versions of the Monty Hall game.

5:00–5:15

A Tale of Two Matrices

Recep Celebi
Lafayette College

What is the relationship between Fourier analysis, quantum mechanics, and group theory? These important topics, all seemingly unrelated at the surface, are actually intimately related in a number of surprising ways. One particularly interesting connection is via the Heisenberg group, which is surprisingly easy to define and understand, given its far-reaching and deep applications. In this talk we will explore some properties of Heisenberg group and the Fourier transform and introduce a selection of applications to quantum mechanics.

5:20–5:35

Diffusion Limited Aggregation and Saffman-Taylor Instability in Non-Newtonian Hele-Shaw Flow

Jimmie Adriazola
New Jersey Institute of Technology

Hele-Shaw flow involves the injection of a less viscous fluid into a more viscous one in a thinly spaced region between two plates. The pattern formation that occurs between Newtonian fluids in this configuration has connections to the Saffman-Taylor instability when considering the driven fluid-fluid interface and solidification structures modeled by Diffusion Limited Aggregation. The aim of this talk is to present studies of this flow when the more viscous fluid has a non-constant shear rate, i.e. the fluid has a non-Newtonian constituency, when displaced. The instability development is quantified in both the experiments and simulations using Fourier analysis and is compared to analytical results obtained by linear stability analysis. This project was carried out over the 2015-2016 school year by the NJIT applied mathematics Capstone class. Partial support by NSF grant No. 1211713 is acknowledged

5:40–5:55

Building an Interactive App for Differential Equations Classrooms

Joshua Haug
Pepperdine University

I am currently designing a new app for the iPad entitled “slopes” that will allow students to plot solutions, tactically explore slopefields and phase planes as well as construct numerical approximations of differential equations. No such app currently exists. The talk will focus on the issues involved in developing such an app and the collaborations with faculty and students in mathematics, computer science, and graphic design that have enhanced the project. Key issues include lexically analyzing and parsing equations, performing efficient evaluations in Swift (for iOS), optimizing numerical algorithms, visualization, and handling errors. Slopes consists of five activities. We have designed each activity to empower students to investigate various concepts in differential equations. “Slopefields” and “Phase Planes” both plot vector fields and solutions corresponding to multiple initial conditions. “Systems” dynamically solves arbitrarily large systems of equations. “Waves” animates the solution of a spring-mass system. ”Methods” interprets equations supplied by the user and constructs numerical approximations using Euler’s method as well as Second and Fourth Order Runge-Kutta methods.

Knox **8:30A.M. – 11:45A.M.**

8:30–8:45

Combinatorial Number Theory

Monica Busser
Youngstown State University

Combinatorial number theory is a recreational field of pure mathematics which aims to approach number theory problems from a discrete and combinatorial point of view. Combinatorial number theory is a relatively young field of mathematics with many unsolved conjectures. In this talk we will explore progress made on some of these conjectures.

8:50–9:05

Representations of Heisenberg Groups

Emily Hoopes
Youngstown State University

The Heisenberg group is generally written as the group of upper triangular matrices with ones down the diagonal while the rest of the entries come from a commutative ring. In this talk, we will specifically work with matrices over finite fields. In representation theory, a group is studied by its actions on vector spaces. One of the fundamental problems in this area is to classify the representations of any given group. We are interested in the representations of the Heisenberg group, and this talk will specifically focus on the one-dimensional representations of the group.

9:10–9:25

Congruences for Two-Rowed Arrays

Kelsey Scott
Grand Valley State University

Congruences for the partition numbers were first established by Ramanujan in the early 20th Century. Since then, arrays called generalized Frobenius partitions have been shown to satisfy the same kinds of congruences. We investigate similar arrays wherein the rows may differ in length and show that number of these objects satisfy analogous congruences.

9:30–9:45

A Group Theory Version of the Lights Out Game

Vasily Zadorozhnyy
Grand Valley State University

The original *Lights Out* game has a 5×5 grid of buttons/vertices that can be toggled and can either be turned on or off. When a player starts a game, some of the lights are on and some are off. When player toggles a vertex, that vertex changes the state of every adjacent vertex and itself. The goal of the game is to toggle vertices in a way such that all lights are off. We are studying a different version of the Lights Out game. All vertices are labeled with elements of $\mathbb{Z}_n$ and when we toggle a vertex, we add the number that is currently on it to every adjacent vertex and itself. For example, when a particular vertex has a label of 4 in $\mathbb{Z}_8$ and we toggle it, it adds 4 to itself and every adjacent vertex, and the label becomes 0. The game gives the set of all possible labelings a digraph structure, where arc of a digraph corresponds to the toggling of a vertex that changes the graph from one labeling to another. In our research we are focusing on connected components of this digraph, and how they are related to some issues of whether or not the game can be won. Such as: how many winnable labelings are there? And if we are in the winnable connected component, are there labelings that are unwinnable?

9:50–10:05

Pell Conics Over Finite Fields

Yulin Zhu
Gettysburg College

Pell conics are a special kind of conics because of some interesting properties. Let d be a squarefree integer not equal to 1 and define

$$\Delta = \begin{cases} d & \text{if } d \equiv 1 \bmod 4 \\ 4d & \text{if } d \equiv 2,\ 3 \bmod 4. \end{cases}$$

Then the curves $\mathbb{C} : X^2 - \Delta Y^2 = 4$ are called Pell conics.
During this talk, I will prove the group law and verify some examples of the group structure of Pell conics.

10:10–10:25

Comparing the Restricted Critical Number and Weakly Zero Sum-Free Sets

Samuel Edwards
Gettysburg College

We define a weakly zero-h-sum-free set as a set where no h-termed sum of distinct elements from the set equals 0. Given a group G and a non-negative integer h, we investigate the maximum size of a subset of G that is weakly zero-h-sum-free, denoted $\tau\hat{}(G, h)$. On a similar hand, we define the restricted h-critical number of a group G to be the minimum value m such that the restricted h-fold sumset of all m-subsets spans the entire group; this value is denoted $\chi\hat{}(G, h)$. These two distinct entities have a specific relationship— that is, $\tau\hat{}(G, h) \le \chi\hat{}(G, h) - 1$. We present the values of $\tau\hat{}(G, h)$ and $\chi\hat{}(G, h)$ for all groups G and sufficiently large h and analyze the situations where $\tau\hat{}(G, h)$ is strictly less than $\chi\hat{}(G, h) - 1$.

10:30–10:45

Polynomial Division in More than One Variable

Jordan G. Hardy

University of Idaho

Most of us are aware of the fact that there is a division algorithm, similar to the one we use for integers, that we can use to divide polynomials in one variable. This is useful because it helps us determine the roots of a polynomial once we already know some of them. It also helps establish that the ring $k[x]$ where k is a field is a Euclidean Domain, and therefore is a Principal Ideal Domain, and a Unique Factorization Domain.

It's also well known that polynomial rings in more than one variable are not Principal Ideal Domains, and since Euclidean Domains are Principal Ideal Domains, these rings are not Euclidean. There is no completely satisfying division algorithm on these rings.

However, all is not lost. Using the idea of a monomial ordering, one can establish a modified division algorithm on multivariate polynomial rings that, while it doesn't have all the qualities we enjoy in one variable, is still useful and, under the right circumstances, still gives us some uniqueness properties.

In this short talk I will introduce the division algorithm and go over a few of its uses.

10:50–11:05

Centers and Generalized Centers of Nearrings without Identity

Brad T. Hall

Wake Forest University (Graduate) and Southeastern Louisiana University (Undergraduate)

The center of a nearring N, in general, is not a subnearring of N. The center, however, is contained in a related structure, the generalized center, which is always a subnearring. We give three constructions of nearrings without multiplicative identity and characterize their centers and generalized centers. We find that the centers of these nearrings are always subnearrings.

11:10–11:25

Exploring the Odds of Generating a Group

Travis Spillum
Saint John's University

For cyclic groups, the probability of picking one random element which generates the group can be determined rather quickly by applying Eulers phi function. What about groups which are generated by more than one element? Determining the probability of generating a non-cyclic group with two elements, let alone more, is complicated by the interactions between the elements. We will be focusing on abelian groups generated by two elements.

11:30–11:45

Degree Six Polynomials and Their Solvability by Radicals

Peter L. Jakes
Elon University

For nearly 500 years, formulas have existed to find exact solutions to quadratic, cubic and quartic polynomials. The existence of such formulas proves that all polynomials of degree less than or equal four are "solvable by radicals." A polynomial is said to be solvable by radicals if its roots can be expressed using the four basic arithmetic operations, the polynomial's coefficients and radicals (square roots, cube roots, etc.). However, it was proven the early 19th century that not all polynomials of degree greater than four are solvable by radicals, and this result is known as the Abel-Ruffini Theorem. A natural question to ask is: which polynomials are solvable by radicals? One approach to answering this question was given by French mathematician E. Galois in the mid-19th century. Galois's research claimed that a function is solvable by radicals if its Galois group is solvable. Consequently, much research is focused on designing and implementing algorithms for computing the Galois group of a polynomial. Currently, most techniques for computing Galois groups employ what are known as "resolvent polynomials," which are auxiliary polynomials that, when factored, provide information about the original polynomial's Galois group. The best method for computing the Galois group of a degree six polynomial was described by H. Cohen in 1993, and this method involves factoring three resolvent polynomials. We improve Cohen's methods by showing that it is possible to improve Cohen's method by using only two resolvent polynomials. Furthermore, we show our method minimizes the number of resolvent polynomials that need to be factored. Using our algorithm, it is straightforward to determine whether a degree six polynomial is solvable by radicals.

Marion **8:30A.M. – 11:45A.M.**

8:30–8:45

Modeling Outbreak of Influenza

Subekshya Bidari
Trinity College

In the spring of 2015, Trinity College experienced an outbreak influenza with forty two reported cases. We use a stochastic SIR-type model to simulate this outbreak and fit the parameters to the data from the Student Health Center using maximum likelihood techniques. In order to better describe transmission patterns at a residential college, we include networks describing the social interactions of students.

8:50–9:05

Analyzing Sexual Transmission in the Spread of the Zika Virus in Colombia

Victoria M. Kelley
James Madison University

Zika has become a global concern for public health due to its devastating birth defects for pregnant women and its rapid spread through Latin America and the Caribbean. In Colombia the outbreak started in October 2015 and since then, 87,355 cases have been reported. The Zika virus is a vector borne disease transmitted through the bite of the female mosquito *Aedes aegypti*, however there is evidence of a sexual transmission route for this disease. Mathematical models are helpful to understand the diseases dynamics and to identify the most important infection routes. Using SIR models as tools, we developed a mathematical model in order to evaluate the role of sexual transmission in the spread of the disease. We evaluated the importance of this pathway for the current outbreak in Colombia.

9:10–9:25

A Discrete Mathematical Model of Newt Population Dynamics in Santa Monica Mountain Streams During a Period of Drought

Marjorie T. Jones
Pepperdine University

We introduce a mathematical model of local newt populations to explore the impact of Californias extreme drought upon newt persistence and to inform the need for and effectiveness of restorative measures. Our model captures the observed decline of California newt *(Taricha torosa)* populations in Santa Monica Mountain streams under drought conditions. We develop a set of nonlinear difference equations to model each life stage of the newt. This allows us to track the population level of each newt life stage by incorporating probabilities for newt maturation and survivorship. In the model, the fecundity of the newt is dependent upon variable precipitation and stream characteristics. We ground our model biologically with local newt population data collected since 1992 from Cold Creek. Our model allows us to forecast newt persistence under long-term drought and other variable rainfall patterns. We make predictions about newt recovery versus extinction following drought that can be used to evaluate the potential success of restorative measures. Based on model simulations we predict how the number of available newt egg-laying sites varies with annual precipitation. Also, we see that even with severe drought, newt populations can rebound if the drought is sufficiently short.

9:30–9:45

Modeling the Walleye Population on Mille Lacs Lake

Daniel Voce
St. John's University

Mille Lacs Lake, located in central Minnesota, has experienced disorder within its natural ecosystem that has led to difficulties maintaining a healthy walleye population balance. Walleye fishing is crucial for the tourist economy so adequate management is essential. We will mathematically model the walleye population present on Mille Lacs Lake. In doing so, we will strive to uncover the original cause of Mille Lacs' walleye crash through the historical data of the Lake and compare this lake with neighboring lakes. Finally, we will use existing patterns to help predict the future of the walleye population and conclude with suggestions based upon mathematical evidence that could help avoid a similar collapse moving forward.

9:50–10:05

Applying the Cancer Stem Cell Hypothesis to the Treatment of Colorectal Cancer

Rebecca B. Hoehne
Saint Mary's College

A mathematical model of the treatment of colorectal cancer is presented and analyzed using a system of nonlinear ordinary differential equations (ODEs). The model describes the effectiveness of immunotherapy and chemotherapy for treatment of tumor cells and cancer stem cells (CSCs). The effects of CD8+T cells, natural killer cells, and interleukin proteins on tumor cells and CSCs under the influence of treatment are also illustrated. Using a localization of compact invariant sets argument, we present conditions on treatment parameters to guarantee a globally asymptotically stable cure state. Numerical and sensitivity analyses of the full model are examined using biologically sound parameters to assess the biological validity of the model.

10:10–10:25

Incorporating Information from Exogenous Variables in Models for Disease Incidence

Jiyi Jiang
Hope College

Dengue Fever, Dengue Hemorrhagic Fever, Chikungunya and Zika are four viral diseases which share a common vector, the Aedes mosquito, which is found in tropical and subtropical regions of the world. Environmental factors play a role in the survival of the Aedes mosquito. Thus, modeling disease incidence trends using environmental data, as well as information about the diseases themselves, would be a viable approach. Various models (both frequentist and Bayesian) for predicting disease incidence using exogenous variables are suggested and compared; with one of the comparison metrics being prediction accuracy.

10:30–10:45

One Bird, Two Bird? Red Bird, Blue Bird? Analyzing Bird Songs Using Wavelets, Image Processing, and Neural Networks Part 1

Allison VanderStoep
Hope College

Biologists, ecologists, and bird enthusiasts want to estimate bird population trends in order to monitor changes in ecosystems. Recently, time-consuming field observations of birds have been augmented by audio recordings of birds. In the lab, we deciphered the quantities and types of birds from a recording. We used wavelet transforms to convert audio signals into images called scalograms. These scalograms display bird songs in a format similar to sheet music; they show how the pitch and volume of a bird's song change over time. After applying denoising and edge detection methods to the images, we trained a neural network to count and identify the birds from the processed images. Although wavelet transforms, image processing, and neural networks are all vital components to analyzing birds calls, this talk will specifically be focused on wavelet transformations.

10:50–11:05

Making Muscles: Math Models of Muscle Formation

Gabbie Van Scoy
Youngstown State University

Muscle formation is an important and complex process. At the beginning, myoblast cells, which are small round embryonic cells, have to transition into myocytes, which are elongated muscle cells. Myocytes then fuse into myotubes, which are the building blocks for muscles. Principles learned from the study of myoblast fusion not only enhance our understanding of myogenesis, but also contribute to our perspectives on membrane fusion and cell-cell fusion in a wide array of model organisms and experimental systems. A computer simulation and a mathematical model is created to help better understand this complex process.

11:10–11:25

Using Machine Learning to Identify Cheaters in Implicit-Association Tests

Zack While
Youngstown State University

An Implicit-Association Test (IAT) is used by psychologists to measure the strength of subconscious associations, aiding in identifying attitudes and biases that patients are unaware of or will not admit. However, participants can manipulate the outcome and invalidate the examination if they are aware of how an IAT works. This talk will discuss the mathematics behind some different machine learning techniques that can be used to identify participants whose results are highly likely to not be honest.

11:30–11:45

Determining Developer Debugging Behavior from Eye Gazes

Jenna Wise
Youngstown State University

Eye tracking equipment is being used to understand how software developers work by providing further insight into what a developer is looking at in source code. Eye trackers have become a popular biometric tool for researchers studying program comprehension. We analyzed an existing eye tracking dataset using TraMineR, an open source R package. The goal is to determine common eye gaze patterns among the different participants and learn about the debugging behavior of experts vs. novices. TraMineR is used for mining, describing and visualizing sequences of states or events, and more generally discrete sequence data. In this talk, we present the results and implications of our analysis and the mathematical details of the routines used in our analysis.

Morrow **8:30A.M. – 11:45A.M.**

8:30–8:45

Computational Mathematics and Minimizing Energy

Lingxi Wu
Indiana University - Purdue University Fort Wayne

Minimal energy configurations have wide ranging applications in various fields of science, such as crystallography, nanotechnology, material science, information theory, wireless communications, etc. Whether one studies electrons in equilibrium, large carbon fullerenes, orifices of pollen grain, or complexity of computation algorithms, distributing points on the sphere in some uniform way plays significant role. In this presentation we shall introduce our mathematical model of optimizing the spherical configurations, show the programming procedures in Maple, and demonstrate the visualizations of the minimization process.

8:50–9:05

Non-Existence of Uniformly Most Reliable Two-Terminal Networks

Hayley Bertrand
St. Norbert College

A 2-terminal network is a network in which resources are assumed to flow from one node, called the source, to another, called the sink. We represent these networks as graphs, where the 2-terminal reliability of such a graph is the probability that there exists a path from the source vertex to the sink vertex when each edge is included with probability p. Given a fixed number of vertices n and a fixed number of edges m, we look for the graph that is most reliable for all p over $[0, 1]$. In this talk, we present specific values of n and m for which a most optimal graph does not exist as well as values of n and m for which there does exist an optimal graph.

9:10–9:25

An Analytic Enumeration of 4×4 Magic Squares

Michael J. Leazer
Carthage College

For my presentation I will first discuss a brief history on the methods of enumerating magic squares of order four. Bernard Frénicle was the first to show in his paper published in 1693, that there are essentially 880 4x4 magic squares. He was able to achieve this result by using a method of exhaustion. It has not been until very recent that a complete analytic approach to enumerating all 4×4 magic squares has been achieved. We have been able to come up with one of these analytic proofs. Our proof is one of only a very few analytical methods to do so. However, our approach is quite different than those that exist today. By focusing on the main diagonal of potential magic squares we were able to group these squares into 6 spaces. Then once each number is converted to binary, many characteristics and properties of 4×4 magic squares begin to surface, furthering our knowledge in the structure of these magical squares. This can easily be shown visually using a 4-dimensional hypercube with each vertex representing a number from the square.

9:30–9:45

Indeterminacy and Twin Open Set Logics

Tiacheng Zheng
Denison University

In standard expositions of Boolean logic, each atomic statement is unambiguously assigned one well-defined truth value an atomic statement is fixed at being true or false. In contrast, when we reason about physical systems—soccer balls or electrons, for example—we use statements whose truth-value depends upon the results of measurements. Physical measurement can never be exact. This suggests that there are situations where atomic statements may be assigned a truth-value of 'indeterminant.' These issues motivated the development of 'twin open set logic.' Our research is aimed at developing a derived modal logic that is built on a foundation of twin open set logic in much the same way as standard modal logic is founded on standard Boolean propositional logic. We address issues such as syntax, semantics, axiomatic bases, and considerations of how 'close' a given twin open set logic can be to Boolean logic. With these foundational issues addressed we turn to extending twin open set logic to a modal type logic where issues such as 'necessity' and 'possibility' can be analyzed.

9:50–10:05

Nature's Numbering System

Rebecca M. Cooper
University of Mount Union

Nature is filled with countless references to the Fibonacci sequence. This research aims to analyze the numerous instances of the Fibonacci sequence, golden ratio, and the golden spiral within the natural world. These mathematical entities are present in animals, plants, and humans. During the research, it was found that animals' reproduction patterns follow the Fibonacci sequence, while several animals contained body parts shaped as the golden spiral. It was discovered that the golden ratio creates an angle for optimal packing in plants, causing them to follow the sequence in order to maintain the highest growth efficiency; this causes most plants to arrange in a spiral fashion. Plants also exhibit the Fibonacci sequence in the branching of stems. Human body proportions exhibit the golden ratio, while their ears mimic the golden spiral. Humans, animals and plants have evolved to grow in the most efficient ways, truly making the Fibonacci sequence one of natures preferred numbering systems.

10:10–10:25

A Modified Amazing Array

Nicholas Heiner
Hendrix College

Values of the form $R = a + 1/(b + 1/(c + 1/(d + \ldots)))$ are known as simple *continued fractions*, and can be rather challenging to reduce with algebra alone, especially if they continue indefinitely. However, mathematical number theory uses a tool known as the *Amazing Array* to greatly simplify this process, ultimately relying only on basic addition and multiplication operations. My project examined the effects of modifying this array, and generalized some of its unique properties.

10:30–10:45

Spheres without 1/k-geodesics

Adam Y. Fong
Trinity College

In this talk we discuss 1/k-geodesics, those closed geodesics that minimize on any subinterval of length L/k, where L is the length of the closed geodesic. We demonstrate metrics on the 2-sphere that do and do not admit 1/k-geodesics for various integers k.

10:50–11:05

The Morley Trisector Theorem for an Isosceles Triangle

Kevin J. Shuman
Edinboro University of Pennsylvania

The Morley Trisector Theorem states that if given a triangle its Morley triangle is equilateral. The Morley triangle being a triangle formed at the intersections of the angle trisectors of the given triangle. This presentation will look at a special case when the given triangle is an isosceles triangle.

11:10–11:25

The Dynamics of Piecewise Isometries of a Torus

Sang Truong
University of California, Irvine

In this talk, we discuss piecewise isometries of a torus. For each such map, we partition the torus into two regions (overlapping on the boundaries is of zero Lebesgue measure), with the property that the restriction of the map to each region preserves distance, hence is a double rotation. We are particularly interested in the synchronization properties of piecewise isometries. To each piecewise isometry of a torus T^2, we associate a nested sequence $A_1 = f(T^2)$, $A_2 = f(A_1)$,... and investigate the stability of this sequence, in order to determine whether the isometry is of finite or infinite type. In addition, we study the topological properties of the set X = intersection of A_i (called the attractor of the map f). By computer simulation, we form conjectures on the dimension of the attractor and its Lebesgue measure. The ergodicity of piecewise isometries in higher dimensional tori is also discussed.

11:30–11:45

Khovanov Homology of Knots and Links

Alexander T. Mathers
University of Alabama

We will look at Khovanov Homology, which is a categorification of the Jones polynomial. To a knot or a link L one can assign a chain complex of graded abelian groups $[L]$, called the Khovanov bracket. With a shift in gradings (analogous to the way the unnormalized Jones polynomial is obtained from the Kauffman bracket) one obtains a link invariant $\mathcal{H}(L)$, called the Khovanov invariant. The graded Euler characteristic of $\mathcal{H}(L)$ is equal to the unnormalized Jones polynomial $\hat{J}(L)$ and the homology groups themselves yield strictly more information, making it a useful link invariant.

Knox **2:00P.M. – 3:15P.M.**

2:00–2:15

DeepYellowJ: Using Mathematics to Develop Chess AI

Ahmad I. Nazeri
Randolph-Macon College

Since the dawn of humanity, humans have always wanted to test their limits. With the invention of computers, a new limitation had arrived; allowing computers to think on their own. The board game of chess is an excellent example of testing this limitation. Since 1950, Programming a Computer for Playing Chess by Claude Shannon has been in the forefront of the solving the problem. The paper discusses the different methods, brute-force and game theory, that can be used to program a computer to play chess. Can we program a computer to play chess intelligently?

2:20–2:35

From Metric to Topology: Determining Relations in Discrete Space

Jordan V. Barrett
Syracuse University

This paper considers the nineteen planar discrete topological relations that apply to regions bounded by a digital Jordan curve. Rather than modeling the topological relations with purely topological means, metrics are developed that determine the topological relations. Two sets of five such metrics are found to be minimal and sufficient to uniquely identify each of the nineteen topological relations. Key to distinguishing all nineteen relations are regions margins (i.e., the neighborhood of their boundaries). Deriving topological relations from metric properties in $\mathbb{R}_2$ vs. $\mathbb{Z}_2$ reveals that the eight binary topological relations between two simple regions in $\mathbb{R}_2$ can be distinguished by a minimal set of six metrics,whereas in $\mathbb{Z}_2$, a more fine-grained set of relations (19) can be distinguished by a smaller set of metrics (5). Determining discrete topological relations from metrics enables not only the refinement of the set of known topological relations in the digital plane, but further enables the processing of raster images where the topological relation is not explicitly stored by reverting to mere pixel counts.

2:40–2:55

Geometric And Computational Representation Of Surfaces And Their Topological Characterization As Quotient Spaces

Jayshawn Cooper
Morgan State University

In this project we explain and logically derive the parametric equations of various surfaces including most notably the Mobius strip and the Klein bottle. We do this by mapping rectangles in the $u - v$ plane $\mathbb{R}^2$ onto the surfaces in $\mathbb{R}^n$ $(n = 2, 3, 4)$. While well-known in the literature, we discovered these formulas and explanations independently in an Inquiry Based Learning (IBL) project. We then, with the help of computer graphics present these surfaces visually. Lastly, we study their topological properties as quotient spaces, proving that the images in $\mathbb{R}^n$ $(n = 2, 3, 4)$ are homomorphic to quotient spaces of the unit square with identications of boundary points.

Marion **2:00P.M. – 3:15P.M.**

2:00–2:15

Proving Global Stability of Processive Phosphorylation Systems

Mitchell J. Eithun
Ripon College

Phosphorylation systems are ubiquitous chemical mechanisms in biology. Using monotone theory we build an all-encompassing processive phosphorylation system and prove that it has unique fixed point and that it is a global attractor. It follows that any n-site processive phosphorylation system that is reversible, irreversible or has product inhibition is globally stable. We present two proofs of this fact: one appeals to monotone theory and the other uses graph reduction.

2:20–2:35

An Exploration of Electron "Jamming" through Spectral Theory

Ben Stortenbecker
University of South Florida

For more than a half a century, we have had experimental knowledge of the metal insulator transition, where the introduction of disorder into a metal causes the electrons travelling through that system to become "jammed", transforming from a conductor into an insulator as a result. Developing a proper theoretical model has been difficult to achieve, leaving the details of this transition poorly understood. In this talk, we will explore the interesting mathematics of spectral theory behind the formulation of a proposed model as well as explore how one would use such a model to understand metal insulator transitions.

2:40–2:55

Advancing Laser Induced Breakdown Spectroscopy for Elemental Analysis of Marine Sediment Samples

Berlinda Rosa Batista
Bridgewater State University

Decades ago, factories and textile mills surrounding New Bedford Harbor, Massachusetts dumped industrial waste into the water which as of today has resulted in sediments contaminated with polychlorinated biphenyls and heavy metals. Over the years, many projects have been introduced in the hopes of cleaning the harbor. With this research, we focus on using Laser-Induced Breakdown Spectroscopy (LIBS) as a technique for detecting heavy metals found in sediments samples taken from the harbor. This study used MATLAB to design a system to statistically analyze the elemental composition of the samples. With LIBS, we used a 30 mJ pulsed Nd:YAG laser to generated plasmas on the wet, dry, and slurry samples. Custom computer code was written to smooth the data in an attempt to display a clear pattern of peaks. The output is a plotted spectrum and a table of the elements found at specific wavelengths. The code focuses on distinguishing the highest peaks of the graphs which identifies elements found in the samples. With the modeled elements, we were able to quantify trends found in specific locations. Moreover, wet, dry, and slurry data are compared. The overall goal here is to advance the real time measurements of sediment samples in the field.

Madison **8:30A.M. – 10:25A.M.**

8:30–8:45

No Talk

Speaker Canceled

8:50–9:05

Digital Image Manipulation: Modern Applications of Linear Algebra

Hannah Grant and Oscar Alvarez

Texas Woman's University

A digital image processor's ability to construct and alter images is related to the simple yet complex coding methods in computing with linear algebra. While using a modern math engine with image processing capabilities, we are applying these methods with the Matlab 2016 software. The primary methods of linear algebra that we use densely involve the manipulation and application of matrices. We are currently working on a series of applications of linear algebra that will be compiled into tutorials for classroom use. In one of our cases, we will take a black and white image and use the strategy of finding the SVD (singular value decomposition) to perform image compression. With this, we are able to minimize the amount of distortion of an image while lessening the memory required for storage. Eigenvalues and eigenvectors are heavily involved in digital image rendering. When stretching and skewing an image, we can use special matrices to stretch across either the x or y axis; this provides the desired effect in a precise and symmetrical manner. With these tools, the tutorials that our team develops will ultimately be presented to an upper level computer science course here at our institution - providing feedback on how these tutorials might be better improved.

9:10–9:25

Accelerated Gradient Descent Algorithms for Image Processing of MRI Scans

Rachel C. Shore

Agnes Scott College

Our image processing research focuses on two simple optimization methods - the gradient descent and the accelerated gradient descent methods - to solve total variation based image denoising and image inpainting models. The purpose of image denoising is to reduce the noise in a fuzzy image while the purpose of image inpainting is to fill in some of the missing or degraded parts. The total variation regularization is very effective in image processing since it is able to provide the sharp edges in the image while suppressing the noise. We code both algorithms and explore the relations between the choices of parameters and the convergence speed. We observe that both algorithms are effective, but the accelerated gradient descent algorithm converges almost three times faster in terms of reduction of energy value versus CPU time/ numbers of iterations. These algorithms can be subsequently applied to parallel magnetic resonance imaging reconstruction problems.

9:30–9:45

Living on the Edge: Improved MRI Reconstruction Using Edge Information

Jade Larriva-Latt, Angela Morrison, Alison Radgowski, and Joseph Tobin
Wellesley College, Albion College, Goucher College, and University of Virginia

Magnetic Resonance Imaging (MRI) is a critical non-invasive tool used by medical professionals to take images of the human body. MR machines work by returning the Fourier coefficients corresponding to the patient being imaged which are then used to reconstruct a picture of the patient. The imaging process is error prone due to, e.g., instrumentation limitations as well as motion by the patient during the scanning process. Additionally, due to the presence of multiple tissues and organs in patients' bodies, the underlying images tend to have a piecewise smooth structure, resulting in imaging errors that distort the boundaries between tissues due to the Gibbs Phenomenon. We propose a highly effective method of detecting edges from Fourier data in order to produce more accurate reconstructions by mitigating Gibbs artifacts. We analytically prove how to detect edges within a given error bound. Using this information, we then describe several advanced sampling and reconstruction methods supported by numerical results that produce quicker, more accurate and robust reconstructions relative to the modern standard.

9:50–10:05

Open Problem on Fibonacci

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 international journal, "The Fibonacci Quarterly." Specifically, I submitted an original solution to an open problem proposed in the May 2014 issue of the journal which was problem B-1147 proposed by Hideyuki Ohtsuka, Saitama, Japan. This problem was just recently selected for publication and was released in the May 2015 issue of the journal.

10:10–10:25

Triangulation Numbers of Arbitrary Polygons

Samuel J. Rogers
Saint John's Preparatory School

In this this talk, we will expand the results of Euler on the number of ways a convex polygon can be triangulated to arbitrary simple polygons. We first count the number of triangulations a diagonal or set of diagonals in a convex polygon is involved in. Second, we apply these results to counting the number of triangulations in general polygons. Several classes of triangulation numbers will be presented to give a fuller characterization to the distribution of triangulation numbers.

Fayette **8:30A.M. – 10:25A.M.**

8:30–8:45

No Talk

Speaker Canceled

8:50–9:05

The Math Behind the Rubik's Cube

Garrison R. Iams

Klamath Community College

Come hear about the intricacies of the Rubik's Cube! I will discuss the history of God's number, which is the least amount of moves it takes to solve a scrambled Rubik's Cube. There are many techniques to solve a scrambled Rubik's Cube. One solution technique which can be modeled by group theory will also be discussed in a way that is understandable to college students who have not yet taken abstract algebra. As an added bonus, I will demonstrate solving a Rubik's Cube in 10 seconds!

9:10–9:25

Conjugacy Classes in $\mathbf{GSp}_6(\mathbb{F}_q)$ and an Application to Abelian Varieties

Jonathan Gerhard

James Madison University

The finite matrix group $\mathrm{GSp}_{2n}(\mathbb{F}_q)$ is the subgroup of $\mathrm{GL}_{2n}(\mathbb{F}_q)$ consisting of matrices that preserve an antisymmetric bilinear form up to scalar multiple. In $\mathrm{GL}_{2n}(\mathbb{F}_q)$, the characteristic polynomial and some additional partition data completely determine a conjugacy class. However, in $\mathrm{GSp}_{2n}(\mathbb{F}_q)$, this is still not enough to uniquely identify a conjugacy class in every case. In $\mathrm{GSp}_6(\mathbb{F}_q)$, we use a parameterization of Shinoda (1980) to construct representatives of certain conjugacy classes and then determine the sizes of those conjugacy classes. As an application, inspired by work of Gekeler (2003) and Achter and Williams (2015), we share progress towards constructing a product formula related to class numbers of number fields of degree 6 and conjecturally to sizes of isogeny classes of abelian varieties of dimension 3.

9:30–9:45

On Cones of Effective Divisors

Nicholas Wawrykow, Connor Halleck-Dube, and Yuxing Wang
Yale University

We study the invariant of algebraic varieties called the cone of effective divisors. We study this invariant for some algebraic varieties constructed from projective space by performing a sequence of blowups along linear subspaces. Our main results have to do with the effective cone of the moduli space of stable rational pointed curves. Our work uses methods from algebraic geometry, convex geometry, combinatorics and some computer work.

9:50–10:05

Geometry of Tropical Tine Arrangements

Scott Weady
Yale University

Tropical geometry has a rich interaction with the combinatorics and incidence geometry of hyperplane arrangements. We explore a new perspective on the tropical geometry of line arrangements in P2, in particular exploring tropicalizations of configurations of arrangements with exceptional properties, such as the Fano arrangement.

10:10–10:25

Mirror Symmetry from Reflexive Polytopes

Chris Magyar
University of Wisconsin - Eau Claire

Mirror symmetry is a mathematical phenomenon occurring in the six-dimensional Calabi-Yau varieties studied in string theory. In our research we explore examples of mirror symmetry in lower dimensional varieties via dual reflexive polytopes. We say a mirror pair of varieties defined by dual reflexive polytopes exhibits strong arithmetic mirror symmetry if the number of points on each variety over a finite field is equivalent, modulo the order of that field. We count points of dual varieties defined by reflexive polytopes over various finite fields and experimentally show that a point counting relationship exists. Using classical methods from elliptic curve theory, we prove this strong arithmetic mirror symmetry relation exists for the two dimensional cases we explore and make several generalizations in the higher dimensional cases backed up by our experimental evidence. Additionally we provide evidence that our surfaces with the same Picard-Fuchs equation exhibit related point counts as well.

Clark **8:30A.M. – 10:25A.M.**

8:30–8:45

No Talk
Speaker Canceled

8:50–9:05

3D Printing in the Mathematics Classroom

Victoria C. Davis
University of North Alabama

Teachers and professors are continuously trying to find ways to connect to students and relate the information in a more relevant way. As I prepare to be a teacher, I think about ways to better convey the material. Three-D printing can be used to make mathematics more interesting, fun, and tangible. Physical, 3-dimensional objects can bring math into a new perspective for students. We consider ways in which 3-D printing can be used in the classroom to make the material more understandable and allow for both a teacher and a student to be actively involved in the lesson and the process of designing a 3-D object. In order to incorporate this, we designed several classroom activities based on concepts that are difficult for students to understand such as calculating volume by washers or cylindrical shells in Calculus II and understanding multiple integrals in Calculus III. These concepts are supplemented by 3-D printing because students can have both a visual and a manipulative. Our activities can be used either as discovery of the material or after a lesson for reinforcement. By completing these activities, we believe it will expand the students understanding of the material.

9:10–9:25

Learning Assistants in Business Calculus Classrooms

Stephen Liddle and Sheeva Doshireh
George Mason University

The learning assistant program was created to integrate strong, knowledgeable students into classes to help college students not only learn the material, but deepen the understanding behind the subject material. Most students taking a mathematics class, especially Math 108, want to learn the steps and formulas without learning the intuition and reasoning behind those steps. Because of this, students tend to find mathematics out of their reach and not applicable to their lives. By integrating learning assistants, we hope to increase the understanding of the material and their interest in the class. A great deal of quantitative data has been collected on the performance of student's grades with and without a learning assistant. However, we wanted to focus on the Math 108 student's views on whether or not Learning Assistants helped increase their grade and understand of the course material. We will show that learning assistants benefit the student's grades, views on mathematics, and help deepen their understanding of their course material.

9:30–9:45

Math Anxiety The Common Plight

Tiffany Klink

Klamath Community College

Numerous learners face math anxiety every day; not just mathematics involved in engineering, but even the basic math skills needed for everyday life. There are multiple causes to math anxiety ranging from actual facts to myths about math. Some topics discussed will be: how adult learners can choose to think about math differently, the fact that there are multiple methods to solve any given math problem, how making mistakes is an important way to learn mathematics, and common causes of math anxiety in adult learners according to research. I will also present several possible solutions to help reduce math anxiety in adult learners today!

9:50–10:05

Determining Student Success and Persistence in Mathematics Courses

Matthew Knight

Lewis University

Persisting through the calculus sequence is one of many hurdles that STEM majors need to complete in order to achieve their degree. Thus, it would be beneficial to predict whether or not students will successfully complete the calculus sequence and other necessary mathematics courses. This talk will expand on a summer project in which we used statistical analysis and machine learning techniques to explore 20 years of data from de-identified transcripts and records from Lewis University calculus students.

10:10–10:25

Is There a Relationship Between Prospective Teachers' Mathematics Background and Proof Scheme?

Amanda M. Akin and Allison B. Bernhard

Lee University

The notion of proof is monumental in how we engage and interact with mathematics. Hence, the purpose of this study was to investigate the possible relationship between proof schemes and mathematical background among prospective teachers. After conducting ten teaching experiments with prospective elementary and middle grades teachers, we analyzed their descriptions of proof, how they engaged with various proofs, and their mathematical backgrounds. Further, using Harel and Sowder's (1998) proof schemes framework, we identified different proof schemes present among the prospective teachers. We found that participants who had encountered proof-based mathematics courses had a tendency to look at problems more analytically, whereas participants who did not encounter proof in their mathematics courses used empirical arguments to solve problems. This difference must be investigated, as these prospective teachers are responsible for communicating mathematics and the notion of proof to their future students.

Champaign **8:30A.M. – 10:25A.M.**

8:30–8:45

Understanding the Center for the 2×2 Linear Iterative System

Lara Kassab, Rami Masri, and Rony Bou Rouphail
Lebanese American University

As in the case of linear systems of differential equations, the study of 2×2 linear iterative systems $Y_{n+1} = AY_n$ leads to an analysis of the eigenvalues and eigenvectors of the system matrix A. The phase portraits of such systems have been examined leading to a complete classification of the equilibrium solution $(0, 0)$ (source, sink, center, $\ldots$). It has been previously claimed that the origin is a center when $\det(A) = 1$ and $-2 < \text{tr}(A) < 2$. In this study we prove that the system solutions in this part of the Trace-Determinant plane either form a closed k-cycle or are attracted to a closed k-cycle, for some k. In addition, we show that the solutions in both cases lie on an ellipse centered at the origin.

8:50–9:05

The Wonders of Digital Art and Fractals: A Project on Visualizations Using R

Eric Lewis, Yanna Chen, and Ricky Hardiyanto
City Tech, CUNY

In this talk, we present several visualization projects designed to mix programming, mathematics and experimentation by creating complex digital art patterns inspired by superpositions of contour and image projections of 2D surfaces. We also developed compact functional programming procedures for visualizing complex fractal systems such as the classical Sierpinski carpet and triangle and the Heighway Dragon, as well as some new fractals that we created. We also implemented some classical chaotic dynamical systems, and developed some interactive 3D visualizations, based on the rgl R library, which we also demonstrate in this presentation. All visualization projects are implemented using the high-level, open-source and free computational environment R. This work is supported by a MSEIP Grant from the Department of Education.

9:10–9:25

Hausdorff Dimension of Fibonacci Word Fractals with Overlap

Joshua Bussiere and Christina Wroblewski
McDaniel College

A Fibonacci word is a string of 0's and 1's generated by a recursive pattern similar to the Fibonacci numbers. Fibonacci curves are generated by implementing a drawing rule where a 1 implies no turn and a 0 implies a turn by angle α either to the left or the right. Taking a scaling limit of these curves, we obtain a Fibonacci word fractal. The Hausdorff dimension has been calculated for Fibonacci word fractals without overlap, when $\alpha \leq \pi/2$. We wish to calculate the Hausdorff dimension for these fractals when there is overlap, when $\alpha > \pi/2$.

9:30–9:45

Self-Similarity and General Scaling Properties in Random Fractals

Konstantin McKenna
Boston University

Fractals are geometric objects that are in some sense self-similar and which lack typical notions of length, area, and volume. A measure of fractal size does exist in the form of the Hausdorff dimension. However, the Hausdorff dimension is more difficult to compute than typical measurements, particularly when a fractal is not strictly self-similar, such a random fractal. We utilize probabilistic methods and the correspondence between trees and fractals to calculate the Hausdorff dimension of randomly generated fractals. In particular, we use general scaling properties - weaker forms of self-similarity that apply even when a fractal is not strictly self-similar.

9:50–10:05

Probablistic Methods to Find the Hausdorff Dimension of a Possible Non Self Similar Set

Jihad Nasser
Michigan State University

Using Potential Theory, it is shown if an arbitrary percolation is performed on an infinite rooted tree, then the probability there is a self avoiding path of retained edges connecting the root of the tree to the boundary of the tree, is bounded below by the Capacity of the boundary of the tree using a general Kernel associated to the retention probabilities.

10:10–10:25

Fractals, and their generation using Iterated Function Systems

Marko Saric
Benedictine University

A fractal is an object that displays self-similarity on all scales. We describe major characteristics of fractals, and their applications. An Iterated Function System is a discrete dynamical system. We study how iterated function systems generate fractals, and determine the conditions on the iterated function system that are needed to graph a fractal. We use these methods to plot the Sierpinski snowflake and other fractals on a computer system.

Madison **2:00P.M. – 3:55P.M.**

2:00–2:15

The Magical World of Sidon Sets

Brady M. Ali Medina

Universidad Nacional de San Agustin

A set $\mathbb{A}$ on an Abelian group $(G, +)$ is a Sidon set if all non-zero differences $a - a'$, with $a - a'$ $\in \mathbb{A}$ are different. What we wonder to know is the largest size may have a Sidon set in $[1 : n]$. This work presents an asymptotic answer to this problem presented in 1932 by the analyst Simon Sidon. In addition, some of the unresolved issues in Sidon sets intervals are presented. Finally, there are some interesting applications of Sidon Sets in the area of telecomunications.

2:20–2:35

A Search for a Bijection Between Two Sets of Tableaux

Danial Wentland

University of Wisconsin Stevens Point

In this talk we explore and explain some of the connections between two different sets of objects, Marked tableaux and $P_{n,2}$-tableaux, that play roles in the representation theory and in algebraic combinatorics. In his paper, Eulerian numbers, tableaux, and the Betti numbers of a toric variety, Stembridge establishes that Marked tableaux give the multiplicity of irreducibles of a representation. Later, in Chromatic Quasisymmetric Functions and Hessenberg Varieties, Shareshian and Wachs come about $P_{n,2}$-tableaux in a similar way, and establish indirectly that there is a bijective correspondence between these two sets of tableaux. We present the results of our research thus far which include: a direct combinatorial bijection between these tableaux for certain shapes, a formula for the number of tableaux for other shapes, and summarize the data collected in a variety of cases.

2:40–2:55

Nucleolus and Group Monotonicity

Matt Chen
Goshen College

A coalition game (N, v) models a situation in which gains can be made by collaboration: $N = \{1, 2, \ldots, n\}$ is the set of players and $v(S)$ is the real-number gain achievable for each nonempty subset S of players (called coalitions). We assume that $v(S) + v(T) \leq v(S \cup T)$ for each pair of disjoint coalitions S and T, because one way for the subset $S \cup T$ of players to collaborate is to work in the separate groups S and T. With this assumption, all players collaborating results in the largest combined payoff $v(N)$. Now the question is how to fairly allocate the gains obtained through collaboration, that is, what payoffs $x_1, x_2, ..., x_n$ should be given to the players subject to the efficiency constraint $\sum_{i \in N} x_i = v(N)$? The nucleolus $\nu(N, v)$ is an allocation method that is group rational: $\sum_{i \in S} \nu_i(N, v) \geq v(S)$ for all coalitions S whenever such an allocation exists. Excess of some allocation x on some coalition S, or $e(x, S)$, is defined as $v(S) - \sum_{i \in S} x_i$, which specifies the "dissatisfaction" that the players in S have against x. The nucleolus is the allocation that successively minimizes the largest excesses. Unfortunately, the nucleolus is not always group monotone: an increase in one of the coalition gains $v(S)$ may result in a decrease in the nucleolus allocation $\nu_i(N, v)$ for some player $i \in S$. We investigate for which coalition games the nucleolus is group monotone.

3:00–3:15

Closed-Forms for Zeroes of Recursive Polynomials

William D. McDermott and Gregory A. Vaughan
Virginia Tech and Purdue University

Consider a recursively defined polynomial sequence given by $G_{0,k} = -a$, $G_{1,k} = x - c$ with $a, c \in \mathbb{R}$, $a \neq -1$, and $G_{n,k} = x^k G_{n-1} + G_{n-2}$. In this paper, we will give a closed form and generating function for $G_{n,k}$. For $k = 1$, we will prove that the maximum real root of G_n denoted by $g_n(a, c)$ and the maximum real root of the derivative of G_n denoted by $g_n^{'}(a, c)$ converge to

$$\frac{c(a+2) + a\sqrt{c^2 + 4a + 4}}{2a + 2} \tag{1}$$

This will generalize a result of Wang and He when $a = c \in \mathbb{N}$. Using the generating function, we will also show that the convergence rate of $g_n(a, c)$ is given by the power law $\mathrm{O}(\frac{1}{\gamma^n})$ where $\gamma = \frac{2}{5}$. Results for $k \geq 2$ will also be presented.

3:20–3:35

Closed Forms of Recursive Polynomial Sequences and Combinatorial Identities

Alexander N. Wilson, Michelle Haver, and Kathleen Lee

Michigan State University, Ohio Northern University, and Whittier College

In this paper we introduce closed forms for some recursively defined polynomial sequences and using the closed forms derive combinatorial identities. One such sequence is the Fibonacci-like polynomials defined by the recurrence relation $P_n(x) = xP_{n-1}(x)+P_{n-2}(x)$ with initial conditions $P_0 = a$ and $P_1 = x + c$, where a and c are arbitrary constants. The closed form of this recurrence

$$P_n = \sum_{l=0}^{\lfloor \frac{n-1}{2} \rfloor} c\binom{n-l-1}{l}x^{n-2l-1} + \sum_{j=0}^{\lfloor \frac{n}{2} \rfloor} a\binom{n-j-1}{j-1}x^{n-2j} + \sum_{j=0}^{\lfloor \frac{n}{2} \rfloor} \binom{n-j-1}{j}x^{n-2j}$$

leads to the following representation of the Lucas numbers for example when $a = 2, c = 0$, and $x = 1$:

$$L_n = \sum_{j=0}^{\lfloor \frac{n}{2} \rfloor} \left[\binom{n-j-1}{j-1} + \binom{n-j}{j}\right]$$

3:40–3:55

On a Modification of the Collatz Problem

Miriam Ramirez

California State University, Northridge

The Collatz problem is investigating the map

$$C(x) = \begin{cases} \dfrac{x}{2} & \text{if } x \equiv 0 \bmod 2 \\ 3x+1 & \text{if } x \equiv 1 \bmod 2 \end{cases}$$

It has remained an open problem to prove that for any positive integer the sequence $x, C(x), C^2(x), \ldots$ will end up in the limit cycle $(4; 2; 1)$. We investigate the map $T : \mathbb{N} \to \mathbb{N}$ defined by

$$T(x) = \begin{cases} \dfrac{x}{d} & \text{if } x \equiv 0 \bmod d \\ mx + r(x) & \text{if } x \not\equiv 0 \bmod d \end{cases},$$

where $r(x)$ is such that $d|(mx + r(x))$ and $0 \leq r(x) < d$. For $m < d$ we have the following:
(i) for any positive integer x the sequence $x, T(x), T^2(x), \ldots$ will end up in a limit cycle,
(ii) if d divides x then $T(x) \leq x - 1$ and if d does not divide x then there exists a positive integer n such that if $x \geq n$ then $T^2(x) \leq x - 1$,
(iii) there are at most $d - 1$ limit cycles $c_1, c_2, \ldots, c_{d-1}$ for all positive integers d and m,
(iv) $\{x \in \mathbb{N} : x \longrightarrow c_j\}$ is infinite for all limit cycles c_j.
We also investigate the special case where $m = d + 1$.

Fayette **2:00P.M. – 3:55P.M.**

2:00–2:15

Continued Fractions and Hilbert Bases of Polyhedral Cones

Cole Johnson and Anna Mikkelsen
Hood College

Special kinds of polyhedral cones in $\mathbb{R}^d$ have a Hilbert basis, which is a minimal generating set for the semigroup of the lattice points within that cone. In $\mathbb{R}^2$, these Hilbert bases can be computed using a specific continued fraction decomposition related to the bounding rays of the cone. We investigate certain cases of these cones and their related Hilbert bases, and relate them to the generating sets of algebraic structures known as intersection algebras, which capture information about how the intersections of powers of ideals grow.

2:20–2:35

On Rational Triangles via Algebraic Curves

Farida Shahata and Mohammad Sadek
American University in Cairo

The study of families of curves as a tool to answer problems concerning rational triangles occupies a thrilling position within fairly recent mathematical literature. For instance, knowing that a positive integer occurs as the area of a right angle triangle with rational sides (known as the congruent number problem) is equivalent to finding a point with rational coordinates on a certain elliptic curve. Thus, establishing a correspondence between sets of rational triangles with certain properties and rational points on curves forms a bridge between two different geometric entities, through which we may infer information on one using the other. In this talk, we will link different sets of rational triangles with a fixed side and rational area to points with rational coordinates on different families of algebraic curves. Constructing such a link reveals an interplay between analytic geometry, algebra and number theory.

2:40–2:55

Computations in Modern Perfect Numbers

Meryn R. Zeigler
The University of Texas

The number 6 has the property that it is the sum, $1 + 2 + 3$, of its proper divisors. Integers with this property are called *perfect numbers*. As their lofty designation suggests, perfect numbers have captivated mathematicians throughout recorded history. Advancements in computing power and the development of new algorithms allow us to expand the scope of this research further than previously possible. We consider an extension of the study of perfect numbers to a modern context, including concepts from algebraic number theory such as ideals and field norms to re-define a sum of divisors function for imaginary quadratic integer rings. We present results, algorithms, and routines from an ongoing computational investigation into definitions of “norm-perfect” algebraic numbers, and we invite discussion regarding the application of this research to the development of novel encryption algorithms.

3:00–3:15

On Quadratic Imaginary Embeddings into Quaternion Algebras

Rose Mintzer-Sweeney, Alexander Schlesinger, and Katherine Xiu
Yale University

We discuss some results regarding embeddings of imaginary quadratic fields into rational quaternion algebras.

3:20–3:35

Analytic Properties of Quaternions

Sanjay A. Raman
Lakeside School, Seattle,

In this paper, we will treat quaternions from an analytic standpoint, generalizing several classical results from $\mathbb{C}$. In particular, we will determine a (non-commutative) set of necessary and sufficient conditions for a function $f : \mathbb{H} \mapsto \mathbb{H}$ to be differentiable in the quaternion variable $\mathfrak{Q} = q + iq_1 + jq_2 + kq_3$ (This condition is stated as $\mathfrak{Q}$-differentiable or $\mathfrak{Q}$-analytic). Using this set of conditions and the Generalized Stokes Theorem, we will prove a non-commutative generalization of Cauchy's integral theorem for (left and right) analytic $f : \mathbb{H} \mapsto \mathbb{H}$ and any closed 3-dimensional surface $\mathfrak{g}$ as well as a formula for an integral over a 1 or 2-dimensional loop $\mathfrak{d}$. At the end, we will briefly reconsider the definition of analyticity and we will document which kinds of $\mathfrak{Q}$-functions can be analytic. This yields rather surprising results of a different nature than those found in the analysis of $\mathbb{C}$.

3:40–3:55

Orbits on Markoff Varieties Over Finite Fields

Alois Cerbu, Elijah Gunther, and Luke Peilen
Yale University

The Markoff Diophantine equation

$$x^2 + y^2 + z^2 = 3xyz \tag{2}$$

has a rich nonabelian group of automorphisms. These automorphisms act on the solutions to (2) over a finite field $\mathbb{F}_p$. We explore some new questions about the cycle structure of certain Cayley-Schreier graphs built out of these group actions, and some of their variants.

Clark **2:00P.M. – 3:55P.M.**

2:00–2:15

Multidimensional Scaling (MDS) Procedure for Investigating Spatial Models of Perception

Cheng Shi

James T. Townsend Lab at Indiana University

Elementary cognitive processes (e.g. Townsend, 1974; Townsend & Ashby, 1983) is based on the notions of architecture (e.g. serial vs parallel), capacity (e.g. unlimited vs limited vs super capacity), stopping rules (e.g. self-terminating vs exhaustive) and stochastic dependence vs independence. Townsend and Nozawa introduced spatiotemporal properties of elementary perception focusing on architecture combining with stopping rules (e.g. Townsend & Nozawa, 1995). Fific and Townsend illustrated the similarities of target and distractor stimuli corresponding to Survivor Interaction Contrast (SIC) function (e.g. Fific & Townsend 2008). According to the results analyzed by Townsend, Nozawa and Fific, my interest is to use the multidimensional scaling (MDS) procedure to investigate spatial models of perception and get some n-dimensional representations of all 16 stimuli and observe whether the n-dimensional representations are the same across four data sets for all human subjects. The Multidimensional scaling (MDS) is an exploratory data analysis technique that attains this aim by condensing large amounts of data into a relatively simple spatial map that relays important relationships in the most economical manner (Mugavin, 2008). MDS can model nonlinear relationships among variables, can handle nominal or ordinal data, and does not require multivariate normality (Jaworska & Chupetlovska-Anastasova, 2009). In order to attain the spatial maps and plot the spatial map into 2-dimensions, R package smacof is required.

2:20–2:35

A Statistically Informed, Algorithmic Approach to Grant Funding

Alexander W. Audet and Brian Darrow Jr.

Southern Connecticut State University

Suppose you were given the opportunity to spend $100,000,000 on improving postsecondary institutions in the United States; how you would spend the money? Answering the aforementioned question requires one to consider how to determine what needs improving and furthermore, which institutions in the United States need it the most. Such a task is particularly difficult since there are so many collegiate institutions in the United States, each with their own strengths and weaknesses. A team of three students in the Mathematics Department at Southern worked together to develop a method of finding the best way to spend $100,000,000 to improve post-secondary education in the U.S. that ensures the highest return on investment (ROI) for the money spent (ROI was defined by the team as well). To do so, the team conducted statistical analyses on a 2011 longitudinal cohort data set provided by the U.S. Department of Education to identify what aspects of collegiate education are essential to providing students with the best education possible. Variables such as graduation rate and retention rate as well as post-graduation measures such as loan default rates and employment after graduation, provided a rich summary of successful collegiate institutions. Using results gleaned from the statistical analyses performed on the data, the students developed an algorithm for ranking 2000 universities based on their level of need for funding. This presentation explores the team's solution to the above project and details SCSU's participation in the 2016 Mathematical Competition in Modeling, which was held January 28th to February 1st.

2:40–2:55

Analyzing Customer Sentiments

Broderick Wagerson
University Of Michigan-Dearborn

The Internet and social media have changed not only shopping methods, but also the way people get information about certain products. What was once passed along by word of mouth is now passed along via product reviews. Customers seek advice online from other customers who have bought products they are interested in, and at the same time share experiences about products or services they purchasedall by means of online reviews. These reviews are literally everywhere on the web and have become a vital part of the economy. Customer sentiment toward products contains information which is tremendously valuable for market analysis and production. However, the large volume of information and the huge number of reviews available online make it difficult to assess customer sentiment on a certain product. But using text mining and machine learning methods, it is possible to extract crucial information from even the largest data sets. In this work, a sample set of 2000 movie reviews are considered and different models are used to predict sentiment of each review as positive or negative.

3:00–3:15

Modeling Fantasy Football Quarterbacks

Kyle Zeberlein and Myles Wallin
Augustana College

Fantasy football is a way to score NFL players based off of their statistics in particular categories. We have created formulas for modeling every quarterback's fantasy football points per game in the 2015-2016 season. Our model is partitioned into four sub-models depending on the length of the quarterbacks career in the NFL. We have developed a weighted model based on previous years' performance of the quarterback, of the defense, and of the quarterback against the defense using data from the NFL. We compare our projections for the season against Yahoos projections for the season.

3:20–3:35

A Computational Investigation of Large Gaps in Contingency Tables

Noah Watson
James Madison University

Integer programming can be used to find upper and lower bounds on the cells of a multi-dimensional contingency table using the information from the released margins. The linear relaxation of these programs also provides bounds and the discrepancy between these bounds, the integer programming gap, can be large. While the more notable examples of large gaps have been shown to be rare. Here we provide some results on the rarity of large gaps on small tables.

3:40–3:55

Dimension Reduction Techniques for Survival Analysis

Daniel Harper and Brianna King
North Carolina State University and Grand Valley State University

Survival analysis is the field of statistics that is concerned with analyzing how long an event of interest takes to occur, for example, death, remission, germination of a plant, breakdown of machine, etc. Some individuals will not have the event by the end of the study (we say their times are censored), and survival analysis techniques correctly account for the censoring issue. A main goal of survival analysis is to try to partially explain the time to event based on other explanatory variables, just as in typical regression settings. However, it is becoming more common (we've all heard of "big data") that the number of explanatory variables greatly exceeds the sample size, which excludes using standard survival regression techniques. A common application would be to use a person's gene expression profile to predict how long he or she survives after diagnosis of some disease. We will compare the performance of different dimension reduction techniques that have been proposed in the statistical literature in the context of survival analysis. This research was conducted as part of the 2016 REU program at Grand Valley State University.

Champaign **2:00P.M. – 3:55P.M.**

2:00–2:15

A Study of the Shortest Perimeter Polyhedron

Kaitlyn M. Burk, Adam P. Carty, and Austin C. Wheeler

Lee University

The purpose of this research is to expand the existing insights on Melzak's Conjecture, which asks the question, "What is the polyhedron in $\mathbb{R}^3$ of unit volume of least total edge length?" That is, what polyhedron has the smallest ratio of total edge length to volume? The least perimeter polyhedron known is an equilateral triangular prism. The study illustrates that the derivative of a regular polygon's area can be related to it's perimeter. A similar technique in $\mathbb{R}^3$ relates a polyhedron's volume, area, and perimeter. After exploring the relationship between second order derivatives of volume and total edge length, this study explores a hypothetical method of proving Melzak's Conjecture.

2:20–2:35

Isoperimetry in the Hyperbolic Plane with Density

Leo Di Giosia

Lewis and Clark College

The isoperimetric problem with a density or weighting seeks to enclose prescribed weighted area with minimum weighted perimeter. According to Chambers' recent proof of the Log-Convex Density Conjecture, for many densities on $\mathbb{R}^2$ the answer is a circle about the origin. We seek to generalize his results from $\mathbb{R}^n$ to the hyperbolic plane.

2:40–2:55

Isoperimetry in Surfaces with Density

Weitao Zhu

Williams College

The isoperimetric problem with a density or weighting seeks to enclose prescribed weighted area with minimum weighted perimeter. According to Chambers' recent proof of the Log-Convex Density Conjecture, for many densities on $\mathbb{R}^2$ the answer is a circle about the origin. We seek to generalize his results from $\mathbb{R}^n$ to some other surfaces of revolution.

3:00–3:15

Least-perimeter Tiles

Dylanger Pittman
Williams College

We seek least-perimeter tiles of Euclidean space and the hyperbolic plane.

3:20–3:35

Double Bubbles in Borel Space

Lea Kenigsberg
Stonybrook University

The planar Double Bubble Theorem says that the least-perimeter way to enclose and separate two prescribed areas in the Euclidean plane is the standard double bubble, consisting of three constant-curvature arcs meeting at 120 degrees. We seek the optimal double bubble in Borel Space, the Euclidean plane with density e^{r^2}.

3:40–3:55

The Best Tetrahedral Tile

Jay Habib
Williams College

Despite what Aristotle said, the regular tetrahedron does not tile space. We seek to prove the optimal (least-perimeter) tetrahedral tile of unit volume.

Madison **4:00P.M. – 6:15P.M.**

4:00–4:15

Dessin D'Enfants and Fields of Prime Characteristic

Eise McMahon
Cambridge University

A dessin d'enfant is a bipartite colored graph on a compact oriented surface. The fundamental theorem of the theory of dessin d'enfants is that a Riemann surface, X, admits a model over $\bar{\mathbb{Q}}$ if and only if there exists a covering $\beta : X \to \bar{\mathbb{C}}$ unramified outside $\{0, 1, \infty\}$. In this case, the rational function β can also be chosen in such a way that it will be defined over $\bar{\mathbb{Q}}$. A Belyi pair (X, β) is a Riemann surface X with a Belyi function β on it. There is a one to one correspondence between a Belyi pair and dessin d'enfants. We aim to realize the Belyi pair over fields of finite characteristic. Purposing a case by case study of surfaces of genus 1, we aim to understand the primes p in which reducing the Belyi pair modulo p results in the genus dropping, singularities developing, or the Belyi function being undefined.

4:20–4:35

Cleaning Threshold Graphs

Rose Winter
St. Catherine University

In the brush-cleaning problem a graph is covered by an instantly-spreading contaminant that must be removed using the fewest possible cleaning agents, or brushes. The minimum number of brushes needed to clean a graph is the graph's brush number, and an ordering that the vertices are cleaned in is a cleaning sequence. Threshold graphs are formed by assigning every vertex a weight between 0 and 1, with an edge existing between two vertices if and only if the sum of their weights is greater than 1. We have determined an algorithm that finds an optimum sequencefor cleaning a subset of threshold graphs, with extensions to the entire set.

4:40–4:55

Spanning Subgraph Isomorphism Using Cut Vertices

Thomas Schuler, Andrew Meier, and Austin Mohr
Nebraska Wesleyan University

An instance of the subgraph isomorphism problem is a pair of graphs T (the target) and H(the host), and we are tasked with determining whether there is some subgraph of H that is isomorphic to T. Practical applications are abound across many disciplines, including the measurement of similarity in molecular compounds, the detection of anomalous activity in telecommunications networks, and the construction of versatile electronic circuitry. The problem is NP-complete in general, which places it among the hardest computational tasks, so there is immense interest in studying heuristic approaches that reduce the size of the search space in practice. We consider a special case of the subgraph isomorphism in which T is known have the same number of vertices as H. Our key new insight is to begin by identifying cut vertices in both T and H, which are vertices whose removal disconnects the graph. By focusing on cut vertices first, we are able to greatly reduce the initial search space, and then proceed recursively on the resulting connected components.

5:00–5:15

Irregular Labelings of Classes of Graphs

Brandon Voigt
College of St. Benedict/St. John's University

Consider a graph $G = (V, E)$ with m edges. Let $f : \{1, 2, ..., m\} \to E(G)$ be a function and define the weight of each vertex to be the sum of the weights of all edges incident to that vertex. If each vertex weight is distinct, G is irregular and f is an irregular labeling. This presentation will discuss irregular labelings on a variety of classes of graphs, particularly trees.

5:20–5:35

Brill-Noether Theory of Finite Graphs

Stanislav Atanasov
Yale University

The Brill-Noether theory of a graph is a discrete and powerful analogue of the Brill-Noether theory on a complex Riemann surface. In recent years, this discrete theory has been used to give new insight into the classical theory. In this talk, we explore the Brill-Noether existence conjecture for finite graphs, which asks when seeks to answer if a naive dimension estimate can be used to predict whether or not a divisor of prescribed numerical criteria exists.

5:40–5:55

Cops and Robbers: The Infinite Chase

Nicholas J. Lindell, Julie A. Bowman, Arthur Diep-Nguyen, Rashmika Goswami, and Dylan C. King
University of Georgia, Southwest Baptist University, Boston College,
University of Michigan, and University of Nebraska Omaha

Cops and Robbers, or the game of pursuit, is a two-player, turn-based game played on the vertices of a finite graph. To start, the cop player C places her cop pawn(s) on the graph, then the robber R his single pawn. Each turn consists of a player moving each of his/her pawns to an adjacent vertex or staying still. C wins if she can "capture" the robber by moving a cop to the vertex R occupies; if not, then R wins. Of mathematical interest are the minimum number of cop pawns required and strategies to ensure that C can always win on a given graph. We examine several of these variations and extend what is known about the classic version of the game to these new settings. In particular, we consider the game on infinite graphs, where C instead wins by "chasing away" the robber by preventing him from visiting any vertex infinitely often. A continuous version of the game where pawns can also be located along edges is mentioned. Applications will be discussed.

6:00–6:15

Estimating Networks of Specialized Knowledge in a Tech Economy

Sirui Wang
Cornell University

The technology sector of New York City has rapidly grown in the past decade, drawing upon well-established firms in the area, as well as new talent from across the world. We study the structure of this emerging community by analyzing social media data from a large online group organized around tech-based startups. We model the organization of knowledge within this group in the framework of Markov random fields and estimate the joint probability distribution of specialized interests using node-wise elastic net regularized logistic regression. The result is a network that encodes the interdependence relationships between various specialized groups in the current New York City tech-startup community. We find that sub-communities in this network are frequently organized around recreational and lifestyle interests in addition to technical skills and business-professional networking. A longitudinal study using this model reveals the rise of programming and data science communities as well as the increasing centrality of facilitated tech-oriented social groups as hubs for interaction and exchange.

Fayette **4:00P.M. – 6:15P.M.**

4:00–4:15

Sums of k-th powers in Quaternion rings

Blake Schildhauer, Annie Marshall, Chung Truong, and Samantha Smith
McDaniel College

Generalization of Warings 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 extend current results to give bounds for $g(3)$ and $g(4)$ for certain Quaternion rings with integer coefficients.

4:20–4:35

Waring's Problem for Hurwitz and Lipschitz Quaternion rings

Samantha Smith, Chung Truong, Annie Marshall, and Blake Schildhauer
McDaniel College

Two different versions of the "ring of integers" exist for the standard Quaternions: the Lipschitz Quaternions, where the coefficients are integers; and the Hurwitz Quaternions, where the coefficients are either all integers or all half-integers. One can then extend Waring's Problem – representing integers as the sum of k-th powers – to either version. We examine the connection between these generalizations of Waring's Problem for Hurwitz and Lipschitz Quaternions over arbitrary Quaternion rings.

4:40–4:55

Exploring Elliptic Curves Using Maple

Dylan McKnight
Saginaw Valley State University

Utilizing the "chord and tangent" method of point addition over elliptic curves, the set of solutions to the elliptic curve equation $y^2 = x^3 + ax + b$ forms an abelian group. When the curve is taken over a finite field, such as $\mathbb{Z}_p$, the resulting finite abelian group's structure can be analyzed, and patterns can be found. In this talk, we will show how to utilize Maple to construct the finite abelian group, add elements of the group, and construct the addition table for the group. From these addition tables, we can see, and work with, the group more clearly.

5:00–5:15

Exploring the Asymptotic Expansion of $\pi^{\frac{2}{6}}$

Laura Beitler and Joshua Zgrabik
Augustana College

This talk will show how to use the high precision capabilities of the mathematical software Sage to find coefficients of the asymptotic expansion of the series 1 + 1/4 + 1/9 + 1/16 + ...

5:20–5:35

Propagation of Values in Binary Sequences

Yujie Jiang and Kenneth S. Berenhaut
Wake Forest University

In this talk we consider the propagation of values in recursive binary sequences. Such sequences have been heavily studied in the context of feedback shift registers. Here we discuss some recent results and conjectures on convergence (and periodicities) of sequences, in terms of number-theoretic properties of elements in underlying delay sets.

5:40–5:55

An Infinitude of Proofs for the Infinitude of Primes

Matt Bradley
Wentworth Institute of Technology

A prime number is any positive number which cannot be divided by anything other than one and itself. It was first proven by Euclid in 300 BC that there are an infinite number of prime numbers. Mathematicians from Greece to Japan have studied the mysterious set of prime numbers. Throughout the ages a multitude of additional proofs for the infinitude of primes have been discovered. These proofs elegantly tie together many branches of mathematics including point-set topology, analysis, and number theory.

6:00–6:15

No Talk

Speaker Canceled

Clark **4:00P.M. – 6:15P.M.**

4:00–4:15

A Local Benford Law for a Class of Arithmetic Sequences

Zhaodong Cai and Matthew Faust
University of Illinois at Urbana-Champaign

It has long been known that sequences such as $\{2^n\}$, $\{n!\}$, $\{F_n\}$ satisfy Benford's law. That is, the frequency of leading digits is not uniform but given by the Benford distribution, $P(d) = \log_{10}(1 + 1/d)$, for $d = 1, 2, \ldots, 9$. In this talk, we investigate leading digit distributions of arithmetic sequences from a local point of view. In particular, we consider the distribution of k-tuples of consecutive leading digits, and we show that most sequences known to satisfy Benford's Law have rather poor local distribution properties.

4:20–4:35

Law of Iterated Logarithm in G_{np}

Austen James, Matthew Larson, and Andrew Salmon
Yale University

The most celebrated result in probably, the central limit theorem (CLT), states that a sum of iid random variables with zero mean converges in distribution to a normal distribution. In the 1920's Khintchine and Kolmogorov furthered proved the Law of Iterated Logarithm (LIL) for the same class or random variables. We present results that have to do with LIL for random variables arising from the random graph G_{np}.

4:40–4:55

Syntactically Informed Text Compression with Recurrent Neural Networks

David R. Cox and J. Maurice Rojas
Texas A&M University

We present a self-contained system for constructing natural language models for use in text compression. Our system improves upon previous neural network based models by utilizing recent advances in syntactic parsing – Google's SyntaxNet – to augment character-level recurrent neural networks. RNNs have proven exceptional in modeling sequence data such as text, as their architecture allows for modeling of long-term contextual information. Modeling and coding are the backbone of modern compression schemes. While coding is considered a solved problem, generating effective, domain-specific models remains a critical step in the process of improving compression ratios.

5:00–5:15

Mathematical Analysis of Lottery Voting

Nicole Buczkowski and Stephanie Thrash
Jacksonville University and St. Edward's University

Standard voting methods rely on deterministic social choice functions to aggregate voter preferences and determine a winner or set of winners. In contrast, lottery voting determines winners by randomly selecting voter ballots. In this talk, we will investigate lottery voting from a mathematical perspective, providing insight into the kinds of situations in which lottery voting may be an appropriate alternative to deterministic methods. This research was conducted as part of the 2016 REU program at Grand Valley State University.

5:20–5:35

Voting Power in Norway's Parliament

Jon Kaasa
Goshen College

The idea of Democracy is interchangeable with equal or "fair" representation. What does equal representation look like in a political system with multiple parties, millions of votes and only a limited integer number of seats to be allocated? We investigate the current apportionment method used in Norway: a proportional representation system where the unit of representation is bound both to territory and to party. The voting power of a political party is not necessarily proportional to the number of seats it controls, and so we make use of power indices defined by Shapley-Shubik, Banzhaf, and Deegan-Packel. In the given context of Norway, we investigate how close the voting powers of the political parties correspond with the number of votes they received, and when it is advantageous for parties to merge together to increase combined voting power rather than stay separated.

5:40–5:55

Paradoxes of Voting: From Lincoln's Presidential Election to College Football Polls

Aubrey R. Laskowski, Vivek Kaushik, and Yukun Tan
University of Illinois at Urbana Champaign

How does the winner of an election depend on the voting methods used? In US politics, we use a plurality system in which each voter chooses a single candidate, but this is not the only possible method. One example is the Borda Count Method used in college football polls. Tabarrok and Spector studied how the outcome of the 1860 US Presidential election would have changed using other voting methods. We performed a similar analysis using data from recent AP college football polls. We found many instances of known paradoxes, such as cyclic majorities (i.e. situations in which team A is ranked above team B by the majority of voters, team B is ranked above team C by the majority of voters, and team C is ranked above team A by the majority of voters).

6:00–6:15

No Talk

Speaker Canceled

Champaign **4:00P.M. – 6:15P.M.**

4:00–4:15

Parallel Curves: properties, visualizations and their realizations over non-smooth curves

Tanya E. Plascencia
University of Central Oklahoma

Two curves are considered parallel if one curve is a constant distance (δ) along the normal from the other. In this presentation, we will define them and present an extension of the definition to non-smooth curves illustrated with remarkable animations. We will show that when these curves are constructed, cusps are formed when the distance from the curve matches the radius of curvature.

4:20–4:35

Generalizations of Solids of Revolution

Daniel H. Hartman
University of West Georgia

The notion of a solid of revolution is typically introduced during the second semester of calculus while introducing integration techniques. The student learns to calculate the volume and surface area of the solids which are revolved around a line. We generalize the idea of solids of revolution from revolving around a line to revolving around a curve. This leads to the concept of compatible curves. Then we give formulas for the volume and surface area of the generalized solids.

4:40–4:55

Outer Billiards and Fundamental Domains

Stephanie Loewen and Tristan Wells
Grand Valley State University and Kansas State University

Outer (Dual) polygonal billiards is a simple plane based dynamical system on a convex polygon. A discrete subgroup of isometries of the hyperbolic plane is called a Fuchsian group if it consists of orientation-preserving transformations. Any Fuchsian group possesses connected, convex fundamental regions. In this project we would like to explore fundamental regions of the outer billiard map defined with regular tilings and possibly quasiregular tilings in the hyperbolic plane. This research was conducted as part of the 2016 REU program at GVSU.

5:00–5:15

Proving The Feuerbach Theorem Using Möbius Transformations

Callie A. Sleep and Dan Kemp
South Dakota State University

The Feuerbach Theorem states that the nine-point circle of a triangle is tangent to the incircle and the three excircles. This theorem is usually proven using inversion in a circle. For this project we have established the necessary properties of inversion through the use of Möbius transformations. Our proof of the Feuerbach theorem also uses Euclidean geometry and algebra.
A Möbius transformation T is a mapping of the complex numbers, $\mathbb{C}$, onto themselves of the form $w = Tz = (az + b)/(cz + d)$ where the complex numbers a, b, c, d satisfy $ad - bc$ does not equal 0. Möbius transformations have numerous geometric properties that allow us to prove that inversion of a circle through the center of the circle of inversion is a line and a circle orthogonal to the circle of inversion inverts to itself. Therefore, in order to present a proof of the Feuerbach Theorem using afore stated Möbius transformations and inversions, a substantial background in Möbius transformations and inversions is necessary. Such presentation will include backgrounds in geometric properties used, Möbius transformations applied, and the necessary inversion techniques along with proof of the theorem.

5:20–5:35

Sphere-Kissing Arrangements and Platonic Solids

Anthony Webb
Northern Michigan University

This project studies "sphere-kissing" arrangements (where spheres are arranged around the outside of a central sphere) in the context of the five Platonic solids. In this talk, we will examine how one can find the circumradii of the five Platonic solids (tetrahedron, cube, octahedron, icosahedron, and dodecahedron) and the relation to sphere-kissing arrangements.

5:40–5:55

Stokes' Theorem on Chains

Nelson Moll
University of California, Irvine

We will prove the generalized Stokes' Theorem over k-chains in n-dimensional Euclidean space and, as a corollary to this result, also prove important theorems from vector calculus such as divergence, Green's and the classical Stokes' theorem. Moreover, using partitions of unity, we can extend generalized Stokes' theorem to integrals on certain well behaved manifolds.

6:00–6:15

No Talk

Speaker Canceled

Madison **8:30A.M. – 11:45A.M.**

8:30–8:45

Truncated Composition Operators

Becca Rousseau and Ruth Jansen
Taylor University

Composition operators are frequently studied on infinite-dimensional Banach and Hilbert spaces of analytic functions. We investigate complex symmetry of composition operators truncated to polynomial subspaces of the Hardy-Hilbert space. Along the way, we find useful eigenvector patterns for truncated composition operators induced by linear maps and their adjoints.

8:50–9:05

Sine-Gordon Equations on Time-space Scale

Zijing Zhang
Kent State University

Sine Gordon Equation was introduced by Edmond Bour (1862) to study surfaces. Sine-Gordon Equation attracted a lot of attention in the 1970s due to soliton solutions. Time-scale calculus was introduced in 1988 by the German mathematician Stefan Hilger. In this presentation, we derive Gordon Type Equations by using AKNS (Ablowitz, Kaup, Newell, Segur) method. Further, we derived solutions of these equations by using Darboux transformation. We also introduce these equations on a Time-scale.

9:10–9:25

Fourth Order Hyperbolic Partial Differential Equations: Time Discretizations and Finite Element Methods

Madison Rowe
Arkansas State University

In this work, we propose fully discrete numerical schemes to solve linear fourth order hyperbolic partial differential equations (PDEs) which describe the transverse motion of *linear buckling beams*. We use time discretizations on a time interval and classical Finite Element Methods over the spacial domain with cubic B-splines. Thanks to eigenfunctions of the static case, an approximated equation of the PDE can be established to obtain its exact solution which will be compared with numerical solutions of the PDE system. Numerical results and simulations are presented as well.

9:30–9:45

Recovering the Potential of Liouville-Sturm Inverse Problem with Data Given on Half of the Interval

Fengyi Li
Texas A&M University

In this paper, we consider the classical inverse Sturm-Liouville problem,

$$-y'' + q(x)y = \lambda y$$

If two spectra $\{\lambda_n\}$ and $\{\mu_n\}$ are given with boundary conditions $y(0) = y(1) = 0$ and $y(0) = y'(1) = 0$ respectively, then the potential $q(x)$ could be fully recovered [Rundell, 1992]. In this paper, we will further investigate that if only one of the spectra, $\{\lambda_n\}$ or $\{\mu_n\}$, is given , and $q(x)$ is known on some intervals $I_n \subset [0, 1]$, where the total length of these intervals adds up to $\frac{1}{2}$, under what conditions can we recover the potential.

9:50–10:05

Positive Symmetric Solutions of a Second Order Boundary Value Problem

Daniel Houston
Eastern Kentucky University

A recent fixed point theorem that is an extension of the Leggett-Williams fixed point theorem is applied to show the existence of a positive symmetric solution of the second order boundary value problem $x'' + f(x(t)) = 0$, $t \in (0, 1)$, with Dirichlet boundary conditions $x(0) = x(1) = 0$. Specifically, we will show how this fixed point theorem can be applied if f is the sum of an increasing and decreasing function.

10:10–10:25

Matrix Differential Equations and Gaussian Elimination

Kevin Garcia
Manhattan College

A derivation $\Delta : M_n(\mathbb{R}) \to M_n(\mathbb{R})$ is a linear transformation satisfying the product rule and can be thought of as a generalized differential operator. A derivation can be used to define matrix differential equations (MDE). In the case of first order, linear, homogeneous MDEs over $M_2(\mathbb{R})$, the possible dimensions for the solution space can be any integer $0 \leq k \leq 4$, except for 3. In this talk we show how to use Gaussian elimination and the CAS Sage to construct and solve such MDEs, as well as prove that a three dimensional solution space is impossible.

10:30–10:45

Multi-Soliton Solutions and their Properties

Jocelyn Z. Correa and Camila Novoa
Texas Woman's University

The solutions of non-linear partial differential equations can be utilized to describe the movement of waves, as seen in the Kadomtsev-Petviashvilli II (KP II) equation, which models surface waves. In this project, we utilize a solution formula for the KP II equation to observe a matrix quadruplet (A;M;B;C), which will be written in terms of matrix exponentials. With this, we will investigate the relationship of the matrix exponentials and the physical properties of multi-soliton solutions. Multi-soliton solutions formulate particular soliton waves that retain their velocity and direction while there is distance between them. By determining specific restrictions on the parameters of the solutions to the KP II equation, we can deduce the velocity and direction of the solitary waves. Using MATLAB we will, additionally, simulate the movement of the soliton waves.

10:50–11:05

Spectrum of Toeplitz Operators with Harmonic Symbols on the Bergman Space

Brandon M. Lee and Michael F. Schigelone
University of Michigan - Dearborn

The spectrum of Bergman Toeplitz operators with symbols of the form $\bar{z} + p(z)$ are known when the polynomial $p(z)$ has degree of at most two. We seek to describe the spectrum of such operators with $p(z)$ being of degree three. Some computational methods and their use for verification will be discussed.

11:10–11:25

Effective Approximations of the Semialgebraic Description ofAmoebas

Nathan Mehlhop
Texas A&M University

The amoeba of a Laurent polynomial is the projection of its corresponding hypersurface under a Log absolute value map. Amoebas have applications in various mathematical subjects. The computation and approximation of amoebas is known to be a challenging problem which has been tackled by several authors in recent years. In this article we demonstrate that an approximation method described theoretically by Purbhoo can be used effectively in practice based on a SINGULAR/SAGEimplementation. We show that the runtime of Purbhoo's original method can be improved significantly via exploiting relations between iterated resultants. Moreover, we show in theory and practice that Purbhoo's method does not only solve the membership problem for amoebas, but that it can also be used to provide an approximation of a semialgebraic description of the Log preimage of the amoeba.

11:30–11:45

No Talk

Speaker Canceled

Fayette **8:30A.M. – 11:45A.M.**

8:30–8:45

An Extension of the Hassell-Comins Discrete Time Model for Two Competing Species

Caryn Willis, Bob Mallison, and Melvin Royer

Indiana Wesleyan University

Multiple discrete time competing species models are looked at including the Leslie- Gowers, Hassell-Comins, and our model. After the Leslie-Gowers and Hassell-Comins models are explored, an extension of the Hassell-Comins model is defined. The equilibria are defined and their conditions for stability are explained. Proofs are given for the instability of $(0, 0)$ and a few conjectures regarding the stability of equilibria are given that make this model interesting. The differences and importance between this model and the Hassell-Comins model show the importance of the continuation of this research.

8:50–9:05

Agent-Based Model for Integrated Pest Management with Periodic Control Strategies

Elizabeth Rodriguez

Benedictine University

We consider an agent-based model (ABM) for integrated pest management (IPM). The model incorporates stage structure for both the pest species and the predator species. In this model, the two control strategies of augmentation of predator species and application of pesticide and the pest births occur periodically at possibly different frequencies. We determine conditions under which either the pest species is eradicated or both species persist. We also investigate how varying the frequency of the augmentation of the predator species and the application of pesticide with respect to the frequency of the pest births affects the amounts of augmentation and pesticide needed to obtain pest eradication and permanent solutions. We then compare the behavior of this model to an analogous model using impulsive differential equations.

9:10–9:25

Investigating the Spatial Effects of Severe Drought on a California Newt Population Using a Compartmental Model

Slade Sanderson

Pepperdine University

The severe drought in Southern California has widespread consequences on the local ecosystem. The California newt *(Taricha torosa)*, an amphibian that is native to the Santa Monica Mountain stream system, is facing population declines due to pressures such as climate change. The current drought in Southern California is limiting the space available for newt oviposition because newts prefer to lay their eggs in deep, slow-moving pools of water. We create a mathematical model to investigate the effects of persistent drought on a newt population in Cold Creek, a pristine creek in the Santa Monica Mountain stream system. We build from a previous discrete model that describes California newt life-stages and expand it to create a spatial compartmental model that represents specific stream segments that can be altered by drought. We use our model to predict the spatial effects of climate change on the newt population in Cold Creek.

9:30–9:45

Using an Agent-Based Approach to Analyze the Effects of Barriers on Crayfish and Newt Population Dynamics

Rachel Schueller
University of Miami

The California Newt *(Taricha torosa)* is a native amphibian species found in the Santa Monica Mountain stream system. The population has been in recent decline leading to local extinctions in some creeks. Their primary predator is the red swamp crayfish *(Procambarus clarkii)*, an invasive species originally from the Southeastern United States. This crayfish is resistant to the newts natural defensive toxins and preys on newt egg masses and larvae. In previous studies and models, it has been shown that extensive trapping of the crayfish can help to protect the newt populations. Natural and artificial barriers have also been shown to moderately hinder crayfish movement between stream segments. I have built an agent-based model that uses the program NetLogo to create a biologically grounded simulation of newt and crayfish population dynamics using extensive local field data. Specifically, this model implements spatial stream components and artificial barriers. The goal of this simulation is to predict the most effective arrangement of barriers within a stream to protect the newt population. We also incorporate previous work on crayfish trapping with the addition of these optimized barriers to simulate the effects that man-made interventions can have on the crayfish population and predict how well these various measures could be implemented to help save local newts.

9:50–10:05

Predicting Newt Persistence amongst Crayfish Populations in Santa Monica Mountain Streams with Manual Crayfish Removal

William Milligan
Emory University

Global amphibian populations are declining, and invasive species contribute to the decline in many species. Predation by the invasive red swamp craysh, *Procambarus clarkii*, on the California newt, *Taricha torosa*, has led to local extinction of the newt in some Santa Monica Mountain streams. Elimination of craysh is difcult, thus the goal of this project is to determine if and to what level could human intervention extend the time to extinction of the newts or foster coexistence between the species. We use delayed, age structured equations to describe newt population dynamics. Crayfish population dynamics are modeled using logistic growth, and a trapping mechanism is validated with field data on the number of crayfish trapped in consecutive months. The interactions between the newt and crayfish species are described using Michaelis-Menten enzyme kinetics and Beddington-DeAngelis predation in a hybrid model. General equilibrium values for newts and crayfish are determined for when trapping does not occur and for simple trapping schedules. Computer simulations demonstrate that intermittent trapping schedules implemented with sufficient frequency and rate of removal can protect newts from local extinction both from an established or invading crayfish population.

10:10–10:25

One Bird, Two Bird? Red Bird, Blue Bird? Analyzing Bird Songs Using Wavelets, Image Processing, and Neural Networks Part 2

Taylor B. Rink
Hope College

Biologists, ecologists, and bird enthusiasts want to estimate bird population trends in order to monitor changes in ecosystems. Recently, time-consuming field observations of birds have been augmented by audio recordings of birds. In the lab, we deciphered the quantities and types of birds from a recording. We used wavelet transforms to convert audio signals into images called scalograms. These scalograms display bird songs in a format similar to sheet music; they show how the pitch and volume of a bird's song change over time. After applying denoising and edge detection methods to the images, we trained a neural network to count and identify the birds from the processed images. Although wavelet transforms, image processing, and neural networks are all vital components to analyzing birds calls, this talk will specifically be focused on neural networks.

10:30–10:45

Green Math: Models of Greenhouse Gasses

Morgan E. Engle and Penny Phan
Southwestern University

We will present mathematical models that analyze data on CO2 emissions for different countries across time. Some factors we consider are fossil fuels, livestock, land use and agriculture. We will illustrate how parameter values, dependent on agricultural practices, account for methane emissions in diverse socio-economic regions of the world.

10:50–11:05

Migration of Yellowfin Groupers during Solar and Lunar Periods

DeWein Pelle and Jared Henley
University of the Virgin Islands

This project, is a continuation of a University of the Virgin Islands study conducted by Richard Nemeth, PhD and Jonathan Jossart, MS which sought to asses a probable location of habitation by theMyteroperca venenosa,yellowfin grouper, within the Grammanik Bank seasonal closure.The yellowfin grouper is a coral reef fish that is prevalent within the western Atlantic Ocean, the Caribbean Sea as well as the Gulf of Mexico. Additionally, the grouper species is believed to live in reef areas with significant depth; however, migration to shallower areas are seasonally common. The aforementioned study utilized passive acoustic telemetry to track and monitor several factors of copious specimens. This current project seeks to utilize existing data to extend the abovementioned study through the application of several probability distribution functions (PDF's), operations used to define the probability of any quantifiable information and its possible outcome, to analyze plausible location for fish spawning.Uniform distribution shows a constant prospect from two foci, or otherwise two locations, in a set area of relatable distribution.Multivariate-normal distribution, a generality of the univariate normal to two or more variables, was also applied. Utilizing these methods with the dataset, we were able to identify probable fish location. Furthermore, the completion of this project assists in the zoning of the Myteroperca venenosa for proper cultivation whilst finding an amendable agreement to allow sustainability for the fishing industry in an avid attempt to avoid the yellowfin grouper's extinction within the Virgin Islands territory.In addition to this, the information is analyzed for migration causations; specifically, lunar and solar periods during the time the data was received. This aspect of the research telescopes on the effect of the previous mentioned periods which have an immense influence on the biological behavior and habitation by the Myteroperca venenosa.This project was funded by NSF HBCU-UP Grant #1137472 grant and while the deploying and maintaining of an acoustic array were funded by numerous agencies including Puerto Rico Sea Grant (#R-31-1-06), NOAA Saltonstall-Kennedy program (#NA09NMF4270068), the Virgin Islands Experimental Program to Stimulate Competitive Research (VI-EPSCoR #NSF-814417) and the Guy Harvey Research Institute.

11:10–11:25

Mathematical Modeling of Human Radicalization

Hsien-Te Kao
California State Polytechnic University, Pomona

In society, human radicalization is commonly associated with negative impressions that are often violent, hostile, and acute. Based on recognition and recall, memorable radicalization representations like discrimination, terrorism, and religious and political ideology have generated strong opinions against radicalization from its destructive impacts on the human race in the past, present, and future. The connection between radicalization and human behaviors in daily life is often overlooked due to these negative impressions. Radicalization also exists in the simplest form of life like someone's expression toward their favorite music artist. Radicalization can bedefined as a progression of human affection that results in the development of extremism. Through social observation, human affection toward an idea is contagious or spreadable to others during a social interaction. By using epidemiological concepts, the progression of a radicalization in a population will be modeled using a modified epidemic model based on the spread of human affection. The eigenvalues of the disease-free equilibrium are analyzed to determine the parameters that affect the stability analysis. A basic reproductive number R_0 is obtained using the next generation matrix approach. Numerical simulations are used to observe the changes in population based on affections. From the results, parameter conditions are established to predict the behavior of a population in a time interval. The purpose of this research is to explore the complexity of the development of human radicalization in a population over time through the usage of epidemiological concepts to construct a simple abstract epidemic model that justifies possible social phenomena outcomes.

11:30–11:45

No Talk

Speaker Canceled

Clark **8:30A.M. – 11:45A.M.**

8:30–8:45

Using the Shingles Vaccine to Stop the Spread of Chickenpox

Katharine Howard and Matt Gilsdorf
Benedictine University

Shingles is a very painful infection caused by the varicella zoster virus (VZV), which is the same virus that causes chickenpox. Because shingles only occurs after someone has been infected with chickenpox and requires the person's immune system to be weakened in some way, shingles tends to occur mainly in adults over the age of 50. However, when an adult has an active shingles infection, he/she is able to spread the virus, and hence chickenpox, to those who have no immunity. Currently, the shingles vaccine Zostamax can help prevent shingles from occurring; however, it is only indicated for adults 50 and older. Because someone with an active shingles infection can spread chickenpox, and shingles can occur at any age, our goal was to try and answer the question: Could using Zostamax for all people who have had a chickenpox infection not only help control shingles, but also have a significant impact on the spread of chickenpox? This talk concerns the setup and discussion of a mathematical model of the spread of chickenpox and shingles along with the implementation of a vaccine to compare the spread of chickenpox under different availabilities of the shingles vaccine.

8:50–9:05

Influence of Climate on Cholera Outbreaks: A Mathematical Model and Analysis

Angel Beltran and Vinodh Chellamuthu
Dixie State University

Cholera is an epidemic disease caused by the bacteria Vibrio cholerae. Despite much research dedicated towards understanding the disease, over 100,000 people die annually from cholera. In order to understand the patterns of infection, we need to better understand the relationship between the bacteria and their aquatic environment under the influence of extrinsic factors such as rainfall and temperature. A mathematical model incorporating a system of non-linear differential equations is developed. The goal is to investigate how variable water levels affect transmission dynamics and outbreak behavior. Stability analysis to both disease-free and endemic equilibria is carried out, and matrix theory is applied to explore the dynamics of the model. We also present numerical simulations to verify the model predictions.

9:10–9:25

A Predictive Probability Model for Diabetes Using Logistic Regression on Clinical Data

Thierno A. Diallo and Andrew Wills
City Tech, CUNY

We developed a predictive model for type 2 diabetes, built on clinical data with eleven variables: age, gender, diabetes (binary), hypertension (binary), systolic and diastolic blood pressure, fasting blood glucose level, low and high density lipoprotein, triglycerides and combined cholesterol. We prepared the data and built a predictive model by doing binary logistic regression, combined with Principal Component Analysis, using R. Binary logistic regression differs from ordinary least squares regression in that the response variable is binary in nature. According to the World Health Organization and the Pan American Health Organization, Diabetes Mellitus is a chronic disease affecting 10% of the worlds population. Early detection is instrumental to combating the disease and greatly improves quality of life. Using data collected from health clinics in the Caribbean island of Nevis, an exploratory data analysis was done to determine which factors have the biggest impact on type 2 diabetes. The overarching goal is developing an interactive Shiny app, implementing the fitted logistic regression model and providing a probability of having type 2 diabetes given a set of values for the predictor variables on which the model depends. Andrew Wills prepared the data and worked with Thierno Diallo on building the predictive model, along with their faculty advisor Prof. Boyan Kostadinov. This work is supported by MSEIP Grants from the US ED.

9:30–9:45

The Dynamics of an Epidemiological Model for HPV with Partial Vaccination in a Heterogeneous Population

Stefano Chiaradonna
Benedictine University

Human papillomavirus (HPV) is the most prevalent sexually transmitted disease in the United States. HPV-16 and HPV-18 are the primary agents of cervical cancer, and HPV-6 and HPV-11 are responsible for most genital warts and juvenile-onset recurrent respiratory papillomatoses. Highly efficacious vaccines have been developed to prevent these high-risk types of HPV, which are typically administered in three doses. We propose and analyze a mathematical model that investigates the implications of having a portion of the population not completing the vaccine regimen. Our model also considers the impact of varied vaccination rates on subpopulations based on the number of sexual partners.

9:50–10:05

Feedback-Mediated Dynamics in a Model of a Long-Looped Nephron

Quinton Neville
St. Olaf College

One of the important mechanisms contributing to renal autoregulation is the tubuloglomerular feedback (TGF) system, which mediates oscillations in tubular fluid pressure, flow, and NaCl concentration at the nephron level. In this study we developed a mathematical model of the TGF system that represents the NaCl transport along a thin ascending limb (THAL) and thick ascending limb (TAL) of a long-loop of Henle with rigid walls. The THAL is an additional segment, which is not found in the short-loop nephron, which extends into the inner medulla and is known to have significantly different physical and functional properties from the TAL. Using our developed model, we investigated the effect of the presence of the THAL on the overall TGF-mediated dynamics of the long-loop nephron. Similar to previous modeling studies, we performed a bifurcation analysis of the TGF model equations that incorporate the spatially-varying i) NaCl permeability and ii) active maximum transport rate, by identifying differing model behaviors as TGF gain and delay values vary. Our model results indicate that the steady-state chloride concentration at the end of the TAL of the long loop is likely to be higher than that of the short loop, and the TGF system exhibits an increased tendency to oscillate. In addition, by varying the THAL's active NaCl maximum transport rate, our model provides useful insights into the impact of the interaction between NaCl permeability and transport rate in the THAL on the TGF-mediated dynamics of the long-loop nephron.

10:10–10:25

Frequency Response of Blood Flow Autoregulation

David Wendl
University of Michigan-Dearborn

Autoregulation is the capability of an organ such as the brain, heart, and kidney to maintain a constant blood flow over a series of changes in arterial pressure within their vascular bed. Since the organs in the human body demand a steady delivery of blood and bio-agents to sustain their metabolic activity, autoregulation is crucial in protecting the organs from both under and over perfusion of blood. In this project, we analyze the validity of a recently developed mathematical model of blood flow autoregulation based on a system of nonlinear ordinary differential equations. Utilizing this model, we are looking for the optimal compliance profile of the blood vessels and the frequency response of the system. Finding the optimal profile will determine the optimal arterial pressure for the fastest autoregulation response to high or low blood pressure. The frequency response will indicate the amount of time it takes for constant flow of blood to return to the circulatory system and therefore, to vital organs. Key words and phrases. Mathematical Modeling; Autoregulatory mechanism. This research project was conducted during the MAA 2016 PIC Math at the University of Michigan-Dearborn and it was sponsored by NSF grant DMS-1345499.

10:30–10:45

Neural Codes: Convexity and Computability

Aaron Chen

Cornell University

Given an intersection pattern of open sets $U_1, ..., U_n$ in Euclidean space, is it possible to determine whether there is an arrangement of the sets such that each set is convex? While appearing purely as a topological/combinatorial problem, this problem was motivated by research in neuroscience as a mathematical model for spatial cognition. Such intersection patterns have been given the name ”neural codes,” as each open set represents a region where a particular neuron will fire when the region is occupied by the animal. We present several new results in this theory, including a proof that the decision problem of determining whether a neural code can be realized by a good cover (a weaker notion than convexity where the sets and all their intersections need only be empty or contractible) is undecidable. We also present a new type of obstruction to convexity in neural codes by considering homotopy invariant collapsings of simplicial complexes.

10:50–11:05

No Talk

Speaker Canceled

11:10–11:25

No Talk

Speaker Canceled

11:30–11:45

No Talk

Speaker Canceled

Champaign **8:30A.M. – 11:45A.M.**

8:30–8:45

Surfaces in knot complements

Michael Moore and Rose Kaplan-Kelly
Columbia University and Bryn Mawr College

Surfaces have played a key role in understanding knots. We will look at new constructions of interesting surfaces associated to knots.

8:50–9:05

The Geometry of Knots

Shruthi Sridhar and Brandon Shapiro
Cornell University and Brandeis University

Most knots can have a hyperbolic metric associated to them, which generates a variety of invariants to tell them apart. We will discuss some interesting examples.

9:10–9:25

Cusp Densities of Hyperbolic Knots

Kiran Kumar and Joshua Wakefield
Williams College and University of Chicago

The cusp density of a hyperbolic knot is the ratio of volume in the cusp to volume in the complement. These values are always known to lie in the interval $[0, 0.853\ldots]$. We investigate their distribution in that interval.

9:30–9:45

Introduction to Coin Configuration Spaces

MacKenna S. Waggener and Madison T. Hays
Pepperdine University

A coin configuration is a collection of coins (closed disks) in a plane such that the union of all coins is connected while the interiors are disjoint, giving the property that each coin is tangent to at least one other coin. The configuration space $\mathcal{C}(r_1, \ldots, r_n)$ includes all coin configurations with n coins having radii $r_1, \ldots, r_n$. Each coin configuration has an associated tangency graph which records the tangent relationships between coins.By studying when the tangency graphs change we get a partition of the configuration space into smaller pieces, which are the flexible spaces. A flexible space then consists of all configurations with the same tangency graph. Building on previous work,we determined the flexible spaces within the configuration space of coins of varying size. We studied how the flexible space changes as the size of the coins affects which tangency graphs are possible and the boundary relationships between flexible spaces.This is joint work with Madison Hays and Joshua Bowman.

9:50–10:05

Homology of Coin Configuration Spaces

Madison T. Hays and MacKenna S. Waggener
Pepperdine University

Homology is an algebraic tool used to understand the structure of a topological space. First we define what we mean by the boundary of a k-dimensional object in the space. Then we consider cycles, which are objects that have no boundary, and compare them with objects that are themselves boundaries. Homology measures the difference between cycles and boundaries. We consider configuration spaces of coins and study them through the lens of homology. Flexible spaces provide a natural partition of a configuration space. We use information about boundaries of flexible spaces together with the tools of homology to piece together this configuration space. This is joint work with MacKenna Waggener and Joshua Bowman.

10:10–10:25

3-Torus Graph Embeddings

Rachel Barnett and Rose Johnson-Leiva
Rutgers University and Quest University Canada

The study of graph embeddings is a central focus of topological graph theory. One technique of determining the surfaces onto which a given graph embeds is called Edmonds' Permutation Technique. This technique associates a cyclic ordering of the edges incident to each vertex in a graph (called a rotation scheme) with an embedding of it into a compact and orientable surface. When the genus (the number of holes) of the surface is one, we obtain a 2-torus embedding of the graph. By examining all the possible rotation schemes for a graph, we can enumerate all the 2-torus embeddings of a graph. This technique is fundamental to one approach of determining all the optimal packings of circles into flat tori. Motivated by our desire to determine the optimal packings of spheres into a 3-torus (a cube with opposite faces identified), this presentation is concerned with generalizing Edmonds' technique to three-dimensional space. In particular, we are concerned with determining all possible embeddings of a graph into a 3-torus so that the embedded graph could be the contact graph of an optimal sphere packing. This presentation will showcase the results of our attempts to accomplish this. This research was conducted as part of the 2016 REU program at Grand Valley State University.

10:30–10:45

Do p-adic Methods Help for Integer Fewnomial Bounds?

Cory M. Saunders
Haverford College

Many real world applications rely on understanding the solutions of polynomial systems, particularly the number of roots. The Fundamental Theorem of Algebra tells us that a polynomial of degree d will have at most d complex roots. However, in many applications we just want the positive solutions. Descartes' rule of signs tells us that the number of positive roots of a single-variable t-nomial $f \in \mathbb{R}[x]$ is at most $t-1$. It would be extremely useful to have a tight generalization of this result to higher dimensions; however, despite decades of work, this is still an open problem.
In this project, we investigate an upper bound on the number of *integer roots* of a family of compactly expressed univariate polynomials $f(x) \in \mathbb{Z}[x]$. We use techniques from p-adic fewnomial theory and the theory of Newton Polytopes to approach this problem. We also discuss a connection to complexity theory via the Shub-Smale τ-conjecture.

10:50–11:05

A Complexity Bound for the Real Zero Sets of n-variate $(n+4)$-nomials

Lucy Yang
University of Minnesota

While classical algebraic geometry has made immense progress in studying the solution set of polynomials over algebraically closed fields such as $\mathbb{C}$, the real roots of a polynomial may differ dramatically from its complex roots, in particular when its degree far exceeds the number of monomial terms. Fewnomial theory aims to characterize the dependence of the topology of the real zero set of a multivariate polynomial on its monomial structure, in particular independently of the degree of the polynomial.
Given a family of polynomials supported on $\mathcal{A}$, the $\mathcal{A}$-discriminant variety $\nabla_{\mathcal{A}}$ describes the subset of polynomials having a degenerate root. The complement of $Re(\nabla_{\mathcal{A}})$ is a disjoint union of connected components, also referred to as $\mathcal{A}$-discriminant chambers. For a given chamber, the topology of the real zero set of functions with coefficients in that chamber is diffeotopic. Thus, for a given support, an upper bound on the number of discriminant chambers implies an upper bound on the number of diffeotopy types of the real zero set of polynomials with that support. Exploiting homogeneities of the $\mathcal{A}$-discriminant variety and using stratified Morse theory, I prove a $\mathcal{O}(n^{24})$ upper bound for the number of diffeotopy types of the real zero set of an n-variate $(n+4)$-nomial.

11:10–11:25

Mystery of Inner Chambers

Erin R. Lipman
Haverford College

Consider the family of n-variate t-nomials with fixed exponent vectors $a_1; ::::; a_t$ in $\mathbb{Z}^n$. Plotting the A-discriminant of this family, namely the subfamily of the coefficient space with singular roots, partitions $\mathbb{R}^t$ into connected components where the underlying real zero set has constant topological type. While the coefficient spaces of certain families of polynomials is of too high dimension to visualize, we can often collapse the discriminant to a lower dimensional space by taking advantage of homogeneities. In particular, the discriminant of an n-variate polynomial with $n + 3$ terms can be collapsed from $\mathbb{R}^{n+3}$ to $\mathbb{R}^2$. For this reason, these families of polynomials are the first important examples whose A-discriminants we can understand well. In particular, the topology of the real zero sets of these polynomials is still not completely understood. We aim to use a recent result of Rusek, giving a sharp upper bound on the number of chambers of the underlying discriminant variety. As a consequence, we derive an $O(n^2)$ upper bound for the number of possible topological types for the positive zero set of an n-variate $(n + 3)$-nomial with fixed exponent set. (The best previous bound was $O(n^{11})$.) This problem is of interest because it is related to a fewnomial version of Hilberts 16th problem.

11:30–11:45

Patterns Relating Self Instersection Number and Word Length for Curves in the Three Punctured Sphere

William Vickery
Stony Brook University

There is a natural way to label each free homotopy class of curves in the three punctured sphere with a word using the alphabet a,b,A,B. The self-intersection number of a class is the smallest number of intersection points of a member of the class. We programmed existing algorithms to compute the self-intersection number of a class in terms of the word, and we used this program determine the number of classes of a given word length and self-intersection number. When the difference between self-intersection number and word length is larger than three, the number of classes exhibits interesting patterns. Along a "line" where the difference between the word length and twice the self intersection number is constant the number of classes is constant. When there are palindromes or words with other symmetries the number of classes will increase along these lines. The goal of our work is to understand these patterns.

J. Sutherland Frame Lectures

2016	Robin Wilson	*Combinatorics - The Mathematics That Counts*
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

2016	Colin Adams	*Zombies & Calculus: A Survival Guide*
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*
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