MAA Student Chapters

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

Pi Mu Epsilon

Pi Mu Epsilon is a national mathematics honor society with 397 chapters throughout the nation. Established in 1914, Pi Mu Epsilon is a non-secret organization whose purpose is the promotion of scholarly activity in mathematics among students in academic institutions. It seeks to do this by electing members on an honorary basis according to their proficiency in mathematics and by engaging in activities designed to provide for the mathematical and scholarly development of its members. Pi Mu Epsilon regularly engages students in scholarly activity through its *Journal* which has published student and faculty articles since 1949. Pi Mu Epsilon encourages scholarly activity in its chapters with grants to support mathematics contests and regional meetings established by the chapters and through its Lectureship program that funds Councillors to visit chapters. Since 1952, Pi Mu Epsilon has been holding its annual National Meeting with sessions for student papers in conjunction with the summer meetings of the Mathematical Association of America (MAA).

Schedule of Student Activities

Unless otherwise noted, all events are held at the Hilton Chicago.

Wednesday, July 26

Time:	Event:	Location:
8:30 am – 12:30 am	PME Council Meeting	Conference Room 5E
3:00 pm – 5:00 pm	CUSAC Meeting	Conference Room 5E
4:30 pm – 5:30 pm	MAA-PME Student Reception	Continental Ballroom B
5:30 pm – 6:15 pm	Math Jeopardy	Salon A-5
8:00 pm – 8:50 pm	Pi Mu Epsilon J. Sutherland Frame Lecture	International Ballroom North

Thursday, July 27

Time:	Event:	Location:
7:30 am – 8:30 am	PME Advisors Breakfast Meeting	*tba*
8:30 am – 10:25 am	MAA Session #1	Lake Ontario
9:10 am – 10:25 am	PME Session #1	Conference Room 4C
	PME Session #2	Conference Room 4D
1:00 pm – 1:50 pm	MAA Chan Stanek Lecture for Students	International Ballroom South
2:00 pm – 3:55 pm	MAA Session #2	Lake Ontario
	MAA Session #3	Lake Erie
	MAA Session #4	Conference Room 4M
	MAA Session #5	Conference Room 4Q
	PME Session #3	Conference Room 4C
	PME Session #4	Conference Room 4D
3:00 pm – 3:55 pm	PME Session #5	Conference Room 4K
4:00 pm – 6:15 pm	MAA Session #6	Lake Ontario
	MAA Session #7	Lake Erie
	MAA Session #8	Conference Room 4M
	MAA Session #9	Conference Room 4Q
	PME Session #6	Conference Room 4C
	PME Session #7	Conference Room 4D
	PME Session #8	Conference Room 4K

Friday, July 28

Time:	Event:	Location:
8:30 am – 11:45 am	MAA Session #10	Lake Ontario
	MAA Session #11	Lake Erie
	MAA Session #12	Lake Michigan
	MAA Session #13	Conference Room 4M
	MAA Session #14	Conference Room 4Q
	PME Session #9	Conference Room 4C
	PME Session #10	Conference Room 4D
	PME Session #11	Conference Room 4K
1:00 pm – 1:50 pm	Activity: Mock Trading with SIG	Continental Ballroom C
2:00 pm – 3:55 pm	MAA Session #15	Lake Ontario
	MAA Session #16	Lake Erie
	MAA Session #17	Lake Michigan
	MAA Session #18	Lake Huron
	MAA Session #19	Conference Room 4M
	MAA Session #20	Conference Room 4Q
2:35 pm – 3:55 pm	Non-Academic Career Paths Panel	Salon A-5
4:00 pm – 5:55 pm	MAA Session #21	Lake Ontario
	MAA Session #22	Lake Erie
	MAA Session #23	Lake Michigan
	MAA Session #24	Lake Huron
	MAA Session #25	Conference Room 4M
	MAA Session #26	Conference Room 4Q
4:15 pm – 5:45 pm	Estimathon!	Continental Ballroom C
6:00 pm – 7:45 pm	Pi Mu Epsilon Banquet	Waldorf
8:00 pm – 9:00 pm	MAA Ice Cream Social and Undergraduate Awards Ceremony	Continental Foyer

Saturday, July 29

Time:	Event:	Location:
8:30 am – 3:00 pm	Preparation for Industrial Careers in Mathematical Sciences Session	International Ballroom South
9:00 am – 10:15 am	MAA Modeling (MCM) Winners	Salon C-4
1:00 pm – 1:50 pm	Activity: Mock Trading with SIG	Continental Ballroom C
1:30 pm – 3:00 pm	Student Problem Solving Competition	Salon C-4
1:00 pm – 4:00 pm	Math Potluck: A Student Swap Session	Salon A-4

J. Sutherland Frame Lecture

BONES AND TEETH: ANALYZING SHAPES FOR EVOLUTIONARY BIOLOGY

Ingrid Daubechies
Duke University

For the last 8 years, several of my students and postdocs as well as myself have been collaborating with biologists to design mathematical approaches and tools that would help automate biological shape analysis. The talk will review this collaboration, sketching both the mathematics and chronicling the interaction with our biological colleagues.

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.

Jean B. Chan and Peter Stanek Lecture for Students

FOUR TALES OF IMPOSSIBILITY

David Richeson
Dickinson College

"Nothing is impossible!" It is comforting to believe this greeting card sentiment; it is the American dream. Yet there are impossible things, and it is possible to prove that they are so. In this talk we will look at some of the most famous impossibility theoremsthe so-called "problems of antiquity." The ancient Greek geometers and future generations of mathematicians tried and failed to square circles, trisect angles, double cubes, and construct regular polygons using only a compass and straightedge. It took two thousand years to prove conclusively that all four of these are mathematically impossible.

MAA Undergraduate Student Activity Session

MOCK TRADING WITH SIG

Todd Simkin and Sam Trabucco
Susquehanna International Group

Join Susquehanna International Group (SIG) for a game that combines the world of trading with mathematical estimation. Working on a team, try to get better estimates for 8 numerical problems than the other teams as quickly as you can if you fall behind, you'll lose valuable opportunities to make money*. The only way to get ahead is to trade with other teams who have worse guesses than you do. Whoever's got the best combination of math skills, strategy, and quick wits will take home the prize* – will you be wolves or sheep? *in-game money is fake, prize money is real!

MAA Student Speakers

Name	School	MAA Session
Sohair Abdullah	Colorado College	18
Alyssa Adams	Youngstown State University	2
Colin Adams	WIlliams College	25
D'Andre Adams	Southwestern University	17
William Adkisson	University of Chicago	25
Santana Afton	College of William and Mary,	19
Kempton Albee	Metropolitan State University of Denver	15
Carlos Albors-Riera	Harvard University	25
Douglas Allaire	Texas A&M University	24
Ashley Amendol	Youngstown State University	2
Amelia Anderson	University of Saint Thomas	14
Lucas Anthony	McDaniel College	9, 15
Katherine T. Arneson	St. Olaf College	23
Chloe Avery	UCSB	15
Don Eliezer Baize	BYU-Hawaii	13
Tim Banks	McDaniel College	9
Tim Banks	McDaniel College	15
Michael Barnett	Amherst College	9
Ruby Bayliss	St. Catherine University	2
Christian Bechler	Goshen College	24
Daniela Beckelhymer	Southwestern University	17
Rabea Begum	New York City College of Technology, CUNY	14
Bret Benesh	The College of St. Benedict/St. John's Univ.	4
Shayna Bennett	Johnson State College	10
Roberto Bertolini	University of Rochester	10
Linda Beverly	CSU East Bay	14
Jack Billings	North Central College	14
Kenan Bitikofer	Goshen College	24
Alexander Black	Hamilton College	7
Eliot Bongiovanni	Michigan State University	13
Caitlyn Booms	University of Notre Dame	15
Darby Bortz	McDaniel College	16
Mirella Boulos	Youngstown State University	1
David Brandfonbrenner	Yale University	12
Milo Brandt	Yale University	14
Jeffrey Braun	Johns Hopkins University	8
Jason W. Bruce	University of Rochester	23
Julia Buczek	Roosevelt University	24
Cody Burker	Franklin College of Indiana	11
Holly Caldes	Montclair State University	7

MAA Student Speakers (Continued)

Name	School	MAA Session
Justin Cameron	Southern Illinois University-Edwardsville	11
Jamylle Carter	Diablo Valley College	4
Alois Cerbu	Yale University	14
Samuel Chamberlin	Park University	21
Jacquelyn Chapman	Youngstown State University	2
Xueying Chen	Borough Of Manhattan Community College	17
Devin Chen	University of Richmond	18
Alanis Chew	Youngstown State University	1
Stefano Chiaradonna	Benedictine University	2
Chineze Christopher	Purdue University	12
Ivan Chwalik	Northern Kentucky University	2
Mukadder Cinar	New York City College of Technology, CUNY	6
Michael Cinkoske	Purdue University	15
Deidra A. Coleman	Philander Smith College	4
Helen Cooney	Neumann University	26
Jocelyn Correa	Texas Woman's University	21
Madison Cox	University of Michigan	2
Emily Dautenhahn	University of Kentucky	17
Paul deVries	LaGuardia Community College	20
Haley Dewey	James Madison University	11
Alejandro Diaz	University of Maryland, College Park	13
Robert J. Dicks	Emory University	12
Duy Doan	Providence College	3
Rei Doko	Michigan State University	9
Emily Dorn	Olivet College	10
Benjamin Doyle	Ferris State University	9
Sally Dufek	Northern Kentucky University	7
Nathan Dwyer	Cornell College	22
Alex Eastwood	Ferris State University	9
Jacole Elliott	Texas Woman's University	21
Alexandra Embry	Indiana University	23
Yazmin Estrada	California State University San Bernardino	12
Emma Fancher	University of North Alabama	14
Xinying Fang	University of Illinois at Urbana-Champaign	8
Alyssa Farmer	Northern Kentucky University	7
Gennifer Farrell	Slippery Rock University	23
Gina Marie Ferolito	Wellesley College	12
Nathan Fiege	Carthage College	16
Alyssa Fortier	University of Arizona	10
Aaron Fowlkes	James Madison University	11

MAA Student Speakers (Continued)

Name	School	MAA Session
Samuel Freedman	University of Michigan	19
Tasha Fu	University of Maryland Baltimore County	12
Andrew Fujikawa	CSU Sacramento	6
John Gaboriault-Whitcomb	Youngstown State University	1
Landon Gauthier	UW-Platteville	14
Abigail Genereau	College of St Benedict	6
Matt Genkin	Stony Brook University	18
Jonathan Gerhard	James Madison University	11
Daniel Gerhenson	Yale University	21
Shrijana Ghimire	New York City College of Technology, CUNY	6
Kirsten Giesbrecht	Centre College	6
Josias O. Gomez	King University	17
Jonathan Gonzalez Davila	Lehman College, CUNY	22
Jack H. Good	Purdue University	4
Antony Gradillas	Ripon College	10
Jessica Greene	Saint Michael's College	25
Philip J. Grossweiler	University of Texas - Rio Grande Valley	10
Alexander Grover	St. Norbert College	23
Elijah Gunther	Yale University	21
Beatrix Haddock	WIlliams College	25
Keri Haddrill	Hope College	10
Sean Haight	Western Washington University	13
Connor Halleck-Dube	Yale University	21
Chance Hamilton	Florida Gulf Coast University	3
Camille Hankel	Georgetown University	6
Maia Hanlon	McDaniel College	9, 15
Ricky Hardiyanto	New York City College of Technology,	18
Marissa Hartsoe	Centre College	18
Joseph Hastings	Northern Kentucky University	7
Hannah Haynie	Youngstown State University	1
Yixuan He	Dartmouth College	26
Christopher Henson	Texas A&M University	26
Shandelle M. Henson	Andrews University	10
Ian Hill	James Madison University	11
Joshua Hinman	Yale University	9
Tim Holdsworth	University of San Diego	24
Caleb Holleman	Taylor University	1
Michael Holmblad	Winona State University	5
Jack Holmes	Johns Hopkins University	8
Alycia Holmes	Roosevelt University	24

MAA Student Speakers (Continued)

Name	School	MAA Session
Brad Horner	University of Nebraska at Omaha	15
Elaine Hou	Yale University	21
Peter Illig	Carleton College	13
Joseph Jackson	Swarthmore College	15
Elias Jaffe	McDaniel College	16
Adrien Jones	Northern Kentucky University	2
Alyssa Jones	The University of Texas at Austin	7
Michelle Jones	Yale University	14
Nicholas Joyner	East Tennessee State University	18
Arjun Kakkar	Williams College	13
Kateryna Kaplun	Montclair State University	12
Yuxuan Ke	Yale University	12
Mitra Kermani	Ripon College	10
Shilpa Khatri	University of California, Merced	10
Daniel Kim	Texas Academy of Mathematics and Science	15
Robert Klemm	University of Saint Thomas	14
Casey Koch-LaRue	Grand Valley State University	18
Anita Kodali	Dartmouth College	26
Boyan Kostadinov	City Tech, CUNY	14
Timothy Kostolansky	Williams College	15
Borys Kuca	Yale University	9
Martial Kuntz	Lawrence Technological University	1
Giancarlo Labruna	Montclair State University	7, 17
Catherine Lee	Yale University	14
Kathleen Lee	Whittier College	21
Karin Leiderman	Colorado School of Mines	10
Qingxia Li	Fisk University	18
Zhiqi Li	WIlliams College	25
William Linderman	King University	17
David Lindow III	Park University	21
Jessica Linton	Benedictine College	10
Baian Liu	Vassar College	14
Ben MacDonald	University of Vermont	10
Mykhaylo Malakhov	Andrews University	10
Sophie Mancini	James Madison University	4
Roummel Marcia	UC Merced	6
Thomas Marge	Johns Hopkins University	8
Harold Maria	Montclair State University	7

MAA Student Speakers (Continued)

Name	School	MAA Session
Alexander Marinkovski	Lawrence Technological University	1
Meraiah Martinez	Benedictine College	6
Amanda Matson	Kent State University	13
Carley Maupin	Lewis University	3
Katherine McClure	University of South Florida Sarasota Manatee	3
Kevin McDaniel	Marshall University	24
Jacob Menix	Western Kentucky University	15
Jennifer Miller	Bellarmine University	25
Zack Miller	Furman University	6
Quinn Minnich	Millersville University	13
Jazmine Morales	Texas Woman's University	21
Nathan Morris	Carthage College	20
Ada Morse	University of Vermont	25
Gabrielle Moss	Johns Hopkins University	20
Timothy Mou	Illinois Mathematics and Science Academy	13
Andre Moura	Yale University	21
Rajatava Mukhopadhyay	Patha Bhavan	23
Cara Mulligan	Centre College	18
Sultan Muratov	Nazarbayev University	8
Hassan Naveed	University of Richmond	18
Bi Nguyen	California State University, East Bay	3
Neil Nicholson	North Central College	14
Daishiro Nishida	Williams College	25
Cara Nix	Univeristy of Minnesota - Twin Cities	6
Sarah Elisabeth Odidika	Youngstown State University	1
Rulon Olmstead	BYU-Hawaii	13
Etude O'Neel-Judy	Northern Arizona University	19
Kira Owsley	Marshall University	12
Karissa Palmer	South Dakota State University,	13
Jungsoo Park	Johns Hopkins University	20
Brenna Peever	University of Idaho	14
Luke Peilen	Yale University	14
Erick Perez	University of San Diego	24
David Perry	Saint Michael's College	25
Julie Phillis	Youngstown State University	2
Sadie C. Piatt	Emmanuel College	10

MAA Student Speakers (Continued)

Name	School	MAA Session
Hannah Pieper	Oberlin College	17
Claire Plunkett	Case Western Reserve University	15
Hashir Qureshi	City Tech, CUNY	14
Sanjay Raman	Lakeside School, Seattle	10
Sara Rat	Nazarbayev University	8
Beth Rawlins	University of Central Oklahoma	11
Ariana Raya	Carthage College	20
James Marshall Reber	Purdue University	12
Henry Reichard	Yale University	12
Braeden Reinoso	Haverford College	25
Devyn C. Rice	Texas A&M University	11
John Risher	University of South Carolina Salkehatchie	1
Patricia Roberts	CUNY Medgar Evers College	10
Nicholas Rockstroh	Bellarmine University	25
Nadia Rodriguez	New York City College of Technology	4
Eric Roon	Metropolitan State University of Denver	15
Jacob Rubinstein	Roosevelt University	24
Katherine Ruddy	Montclair State University	7
Jonathan Sahagun	CSU Los Angeles	6
Shyam Sai	Illinois Mathematics and Science Academy	17
Mary Lib Saine	Furman University	6
Joel Salazar	California State University San Bernardino	12
Alison Sall	James Madison University	11
Andrew Salmon	Yale University	14
Jesus Sambrine	Kent State University	8
Matthew Samsel	William Jewell College	21
Katharine Sanderson	Montana State University	6
Joseph M. Sauder	Pontifical Catholic University of Puerto Rico	12
Carl B. Schildkraut	Lakeside School, Seattle	10
Alexander Schlesinger	Yale University	9
Paige Schoonover	University of Tennessee	15
Michael W. Schroeder	Marshall University	12
Jason Schuchardt	Yale University	21
Ethan Sciamma	Yale University	12
Leah Seader	California University of Pennsylvania	3
Alex Semendinger	Williams College	15
Parker Servello	Slippery Rock University	23

MAA Student Speakers (Continued)

Name	School	MAA Session
Thomas Settlemyre	Texas A&M University	20
David Shane	Methodist University	5
David Shane	Grand Valley State University	12
Farjana Shati	New York City College of Technology	11
Meredith Sheeks	Lee University	26
Suzanne Sindi	UC Merced	6
Aditya Sivakumar	Beaverton High School	11
Carter Smith	University of Texas at Austin	5
Michael Smith	Purdue University	4
Cassia Smith	University of the Virgin Islands	7
Collin Smith	Cornell College	11
Brenna Smith	Saint Michael's College	25
Nat Sothanaphan	Massachusetts Institute of Technology	13
Melissa Spence	UC Davis	6
Cameron Stopak	James Madison University	11
Shane Storks	Lawrence Technological University	1
Blandon Su	University of Illinois at Urbana-Champaign	8
Joseph Suk	Stony Brook University	18
Nicole Sutherland	James Madison University	11
Mark Sweeney	University of Rochester	20
Savannah V. Swiatlowski	Central Michigan University	10
Renee Swischuk	Texas A&M University	24
Chun Szeto	New York City College of Technology	4
Luke Szramowski	Slippery Rock University	9
Joshua Teeter	Florida Gulf Coast University	3
Sandra Torres	City Tech, CUNY	14
Khoa Tran	University of Illinois at Urbana Champaign	22
Jennifer Travis	Lone Star College-North Harris	4
Chung Truong	McDaniel College	9, 15
Lucas Tucker	University of Saint Thomas	14
Jeffrey Tumminia	New York City College of Technology	16
Hwai-Ray Tung	Brown University	10
Angel Tuong	McDaniel College	9, 15
Obinna Ukogu	Amherst College	9

MAA Student Speakers (Continued)

Name	School	MAA Session
Jacob Van Hook	Pennsylvania State University	4
Danika Keala Van Niel	Syracuse University	12
Paul Vienhage	Emory University	19
Nick Wahl	University of San Diego	24
Dorothy I. Wallace	Dartmouth College	26
Catherine Wallick	St. Catherine University	12
Luya Wang	Princeton University	25
Mark Daniel Ward	Purdue University	4
Tykeena Watson	Fisk University	18
Jordan Weathersby	Carthage College	16
Jack Wesley	Amherst College	9
Elanor West	Johns Hopkins University	8
Yandi Wu	University of California, Berkeley	22
Fan Wu	University of Illinois at Urbana-Champaign	8
Annie Xie	Johns Hopkins University	8
Hui Xu	Amherst College	9
Michelle C. Xu	Arnold Beckman High School	7
Andrea Young	Ripon College	10
Qimeng Yu	Carleton College	13
Lei Zhang	BMCC, CUNY	14
Anan Zhang	Johns Hopkins University	8
Yunfan Zhao	Johns Hopkins University	8
Ruoyu Zhu	University of Illinois at Urbana-Champaign	8
Maksym Zubkov	University of California, Irvine	25

Pi Mu Epsilon Speakers

Name	School	PME Session
Stephanie Ann Allen	State University of New York at Geneseo	6
Zachary J. Ash	Grand Valley State University	3
Jordan Vincent Barrett	Syracuse	5
Uttam Bhetuwal	Troy University	10
Claire Bodemann	Eckerd College	4
Jeremiah Bouza	Kent State University	2
Monica Ellen Busser	Youngstown State University	9
Sarah Chamberlain	SUNY Fredonia	1
Rebecca M. Cooper	University of Mount Union	11
Brian D. Darrow, Jr.	Southern Connecticut State University	6
Niyousha Davachi	University of Texas at Arlington	7
Trent DeGiovanni	Gonzaga University	10
Ashraf Demian	Texas State University	7
Lydia M. DeMorett	College of St. Benedict/St. John's University	8
Simon Deng	University of Nebraska-Lincoln	8
Dayle Duffek	St. Norbert College	11
Elise Eckman	Youngstown State University	9
Jessie M. English	The University of Texas at Tyler	8
Donald Wayne Fincher	Kent State University	2
Noah Dane Froberg	St. John's University	9
John Augustus Haug	University of Illinois in Champaign-Urbana	11
Jason Bailey Heath	Gettysburg College	3
Russell P. Houpt	Hope College	8
Travis A. Howk	Hendrix College	10
Robert Krueger	Miami University	6
Christine C. Langer	Youngstown State University	11
Madel Roque Liquido	Saint Peter's University	8
Colleen Mandell	St. Norbert College	4
Sophia M. Maniscalco	Bridgewater State University	1
Katherine A. Mantych	Elmhurst College	3
Britney Mazzetta	Ithaca College	4
Nicholas P. Meyer	Winona State University	10
Sarthak Mishra	Troy University	6
Eric Louis Montag	Randolph-Macon College	2
Phuc Nguyen	Marquette University	6

Pi Mu Epsilon Speakers (Continued)

Name	School	PME Session
Joseph S. O'Brien	Southern Connecticut State University	9
Brandon Payne	Elmira College	11
Michael Pearce	St. Olaf College	10
Bryan Pennington	University of Texas at Tyler	3
Yansy E. Perez	University of Texas at Tyler	9
Michelle Emily Persaud	SUNY Fredonia	10
Danielle D. Pham	Creighton University	4
Kiersten Potter	Marshall University	10
Lexi Elaine Rager	Youngstown State University	11
Kristen Kaylene Reihl	University of Mount Union	9
Steven M. Rollins	Marshall University	7
Marleah Roseman	SUNY Fredonia	9
Slade Sanderson	Pepperdine University	5
Marko Saric	Benedictine University	1
Parth Sarin	Texas A&M University	10
Candyce Sarringar	Hendrix College	11
Sarah Jean Seckler	Hope College	8
Brittany Sheahan	St. Norbert College	4
Emily Simon	St. Norbert College	11
Callie A. Sleep	South Dakota State University	10
Annie Small	Juniata College	9
Kevin Smith	University of California, Irvine	10
Rebecca Caryl Sorsen	University of Nebraska-Lincoln	5
Taylor R. Stacey	Augustana University	7
Hanna Strohm	St. Norbert College	4
Erika Sweet	Santa Clara University	7
Sieu K. Tran	Virginia Tech	9
Ngan N.P. Tran	Ripon College	11
Vincent Houser Villalobos	University of Texas at Tyler	1
Anh Thuong Vo	Creighton university	2
Joshua R. Wagner	Gettysburg College	6
Jack Wagner	Armstrong State University	9
Erik L. Wendt	Gettysburg College	7
Yutong Yang	Kennesaw State University	3
Vasily I. Zadorozhnyy	Grand Valley State University	3
Jie Zhang	UC Irvine	8
Ruoyu Zhu	University of Illinois at Urbana-Champaign	6

Lake Ontario **8:30A.M. – 10:25A.M.**

8:30–8:45

On Some Inequality Problems

John T. Risher
University of South Carolina Salkehatchie

On Some Inequality Problems In Cvetkovski's book "Inequalities-Theorems, Techniques and Selected Problems", we notice that there are several inequalities involving sums of symmetric fractions with three variables. Using mathematical induction and applying AM-GM inequality, we provide a more generalized version of these inequalities, and prove that our new result also works for sums of fractions with n variables.

8:50–9:05

Binormal, Complex Symmetric Operators

Caleb Holleman
Taylor University

In this paper, we describe necessary and sufficient conditions for a binormal or complex symmetric operator to have the other property. Along the way, we find connections to the Duggal and Aluthge transforms, and give further properties of binormal, complex symmetric operators.

9:10–9:25

Integration By Parts and Series

John Gaboriault-Whitcomb
Youngstown State University

Infinite series and integration by parts are both topics taught in elementary calculus classes, and seemingly are not related in their applications. A college calculus student possibly proved that conjecture wrong when she approached an integration by parts problem the "wrong" way by switching the traditional "u" and "dv" terms when attempting $\int xe^x dx$, and found the correct answer $xe^x - e^x + C$ by using the infinite series found. This integration by parts technique can be used on functions such as $\sin(x)$ and $\cos(x)$ to find obvious relationships to known infinite series, but has yet to be explored with many other functions. Uses and applications of this technique with different functions are explored in this presentation.

9:30–9:45

Life Saving Myogenesis: A Mathematical Representation of Muscle Formation, Part 1

Hannah Haynie and Sarah Elisabeth Odidika

Youngstown State University

Orthopedic birth defects are a growing health concern that will decrease one's quality of life beginning at infancy. According to the Centers for Disease Control and Prevention, every 1 in 33 babies are born with a birth defect. Birth defects are the leading cause of infant mortality, accounting for 20 percent of all infant deaths. By utilizing MatLab, we have created an agent based model of muscle cell development, which follows a cell through the journey from myoblast to muscle fiber. This program can be used to better understand the process of muscle formation during fetal development and to test different biological hypotheses. Different stages of muscle growth or inhibition will be reproduced by mathematical modeling through the use of MatLab to gain a better understanding of myogenesis through early childhood. Although we are in the beginning stages of research, our ultimate goal is to use this knowledge collected through mathematical simulation to provide further information to aid in decreasing the incidence of orthopedic birth defects.

9:50–10:05

Life Saving Myogenesis: A Mathematical Representation of Muscle Formation, Part 2

Mirella Boulos and Alanis Chew

Youngstown State University

Orthopedic birth defects are a growing health concern that will decrease one's quality of life beginning at infancy. According to the Centers for Disease Control and Prevention, every 1 in 33 babies are born with a birth defect. Birth defects are the leading cause of infant mortality, accounting for 20 percent of all infant deaths. By utilizing MatLab, we have created an agent based model of muscle cell development, which follows a cell through the journey from myoblast to muscle fiber. This program can be used to better understand the process of muscle formation during fetal development and to test different biological hypotheses. Different stages of muscle growth or inhibition will be reproduced by mathematical modeling through the use of MatLab to gain a better understanding of myogenesis through early childhood. Although we are in the beginning stages of research, our ultimate goal is to use this knowledge collected through mathematical simulation to provide further information to aid in decreasing the incidence of orthopedic birth defects.

10:10–10:25

Simulating Hot Topic Popularity with A Modified SIR Model

Shane Storks, Martial Kuntz, and Alexander Marinkovski

Lawrence Technological University

We used a system of three ordinary differential equations to model and predict the trends of hot topics on the Internet. Our mathematical model is based on the classic SIR model that simulates the number of people infected with a contagious disease over time. We modified it to model the popularity of hot topics over time as recorded by Google Trends. Although the propagation of hot topics over the Internet is a random process, our numerical analysis demonstrates that it can be simulated and predicted by the rather simple deterministic model very well.

Lake Ontario **2:00P.M. – 3:55P.M.**

2:00–2:15

A Mathematical Simulation of Bone Cell Behavior Part 1

Julie Phillis and Alyssa Adams
Youngstown State University

Bone metabolism is an intricate process involving osteocytes, osteoblasts, and osteoclasts. Osteoblasts are the cells responsible for generating new bone in the body, osteoclasts are responsible for the natural degradation of bone, and osteocytes are simply bone cells. All three of these types of cells must work together in perfect balance to successfully maintain homeostasis. The focus of this talk is on osteoblasts and their behavior in the body. A mathematical model was created in an attempt to replicate the natural formation of bone and see if it was a valid and accurate model.

2:20–2:35

A Mathematical Simulation of Bone Cell Behavior Part 2

Jacquelyn Chapman and Ashley Amendol
Youngstown State University

The primary function of bones involves three different cells: osteoclasts, osteoblasts, and osteocytes. Osteoclasts are large bone cells that absorb bone tissue, osteoblasts are cells that create new bone, and osteocytes are essentially osteoblasts that have been trapped in the secreted bone matrix. All three cells work together concurrently and are responsible for what the bone is able to do on a daily basis to maintain homeostasis. This talk focuses on one of these three cells, osteoclasts. The research done was in collaboration with the Biomedical Engineering Department at The University of Akron, who provided the lab work. A mathematical model was developed in order to simulate the behavior of these cells in the lab.

2:40–2:55

Using Image Analysis and Machine Learning Algorithms for Classification of Harmful Algal Blooms

Adrien Jones and Ivan Chwalik
Northern Kentucky University

Reports of toxic cyanobacterial blooms, also known as Harmful Algal Blooms (HABS) have increased drastically in recent years. HABS impact human health from causing mild allergies to liver damage and death. Northern Kentucky University is developing a smart device application that will permit accurate and quick identification of potential HABS. This new application, titled HAB APP, will be used to assist identification of HABS in recreational and drinking water supplies. Using support vector machine computer learning algorithms, the smart device extracts a color histogram from an image and compares it with a pre-loaded trained model of images for classification. More specifically, the algorithm distinguishes between relatively harmless green and potentially harmful blue-green algae. The algorithm will be extended to classify images taken from cameras situated along the Ohio River and is planned to include classification at the microscopic level.

3:00–3:15

Investigating Examples of Non-Convex Open Neural Codes

Ruby L. Bayliss

St. Catherine University

The study of neural codes is motivated by the need for a mathematical model of an interaction of place cells in the hippocampus. We define a codeword to be a subset of $[n] = \{1, 2, \cdots, n\}$, and a neural code $\mathscr{C}$ to be a subset of $\mathscr{P}([n])$. A code $\mathscr{C}$ on n neurons corresponds to the fiering patterns of these neurons. An open convex cover of a neural code is a collection of open sets whose nonempty intersections correspond to the codewords within the code. However, not all neural codes have an open convex cover. Curto et. al. developed a property of codes called local obstructions, whose existence implies that a code does not have an open convex cover. Previously, Lienkeamper et. al. found the existence of an open non-convex code without local obstructions. We extend the results of Lienkeamper et. al. to demonstrate more examples of non-convex codes without local obstructions, with the goal to find a whole class of non-convex codes without local obstructions.

3:20–3:35

Mathematically Modeling the Impact of Invasive Crayfish Removal on Endangered Steelhead and Rainbow Trout Persistence in the Santa Monica Mountains

Madison Cox

University of Michigan

Steelhead and rainbow trout comprise one species, *Oncorhynchus mykiss*. Steelhead trout are anadromous *O. mykiss* that migrate between the ocean and freshwater streams to spawn; rainbow trout remain in their natal freshwater stream for life. In addition, anadromous trout have much higher fecundity than resident rainbow trout. The populations of California's native *O. mykiss* that live in streams connected to the Pacific Ocean are endangered due to habitat loss, drought, and predation by invasive crayfish (*Procambarus clarkii*). The recent historic California drought has decreased the connectivity of the spawning streams to the ocean and has limited the anadromous members' ability to reach spawning grounds. This is exacerbated by reduced reproductive success due to crayfish predation upon eggs and young trout. Recent conservation efforts focus in part on removing crayfish to boost *O. mykiss* survival. We create a discrete compartmental model of *O. mykiss* life history dynamics in Topanga Creek. We incorporate a model of invasive crayfish trapping and use numerical simulations and sensitivity analysis to investigate which crayfish trapping regimes most benefit *O. mykiss* persistence in Topanga Creek. The model is generalizable to endangered *O. mykiss* populations in other streams. Model results inform invasive crayfish removal efforts and aid *O. mykiss* conservation efforts.

3:40–3:55

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

Stefano Chiaradonna
Benedictine University

The Human papillomavirus (HPV) is one of the most prevalent sexually transmitted diseases 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. However, younger adolescents need only two-doses of the full three-dose vaccine regimen [CDC]. We propose and analyze a mathematical model that investigates the implications of the population not completing the vaccine regimen as well as the scenario of younger adolescents receiving one-dosage. Our model finds a sufficient, vaccination strategy for certain age groups based on gender and the number of sexual partners. By having differing age groups, the model can target specific age group for vaccination to optimize the control of HPV spread, which could lead to the eradication of the disease. CDC Recommends only Two HPV Shots for Younger Adolescents, 2016. Centers for Disease Control and Prevention, https://www.cdc.gov/media/releases/2016/p1020-hpv-shots.html.

Lake Erie **2:00P.M. – 3:55P.M.**

2:00–2:15

Predictive Modeling and Analysis of Softball Using Linear Algebra

Carley Maupin
Lewis University

Ranking sports teams can be a challenging task and using only win percentage can be misleading at times. Among the many mathematically inspired sports ranking systems, the Massey and Colley methods are among the most elegant and simple. Both involve setting up and solving a matrix system. While at their most basic level, these methods are useful for sports rankings, unfortunately, they are not particularly strong at predicting future outcomes of games. One way to improve these methods for ranking and predicting future outcomes is by introducing weights to these systems. In this talk, we will discuss the results of a summer research project in which we created and tested the predictive power of different weighted Colley and Massey methods using data from softball teams in the Great Lakes Valley Conference.

2:20–2:35

University Honors Program Statistical Analysis

Leah Seader
California University of Pennsylvania

The California University of Pennsylvania Honors Program was seeking forethought on different aspects of the program in regards to statistics of graduation rates, retention rates, and diversity. Preliminary research was conducted on what types of information other University Honors Programs had collected to help improve their programs. Different models were assessed and created to see which style would best fit the information of focus. The next step was to complete an assessment by drafting specific research questions for students to complete. A preliminary form was then created to upload onto SurveyMonkey which allowed the students names to remain anonymous. Since the forms were completed online with anonymity, the answers would be credible. Upon receiving IRB approval, the link to the survey was sent out to the students. Once all of the surveys were gathered, the data was processed, organized, and analyzed. The SPSS model was used to analyze the data to locate any trends and to determine if the data was relevant.

2:40–2:55

Statistical Correlation of Factors Associated with Liver Cancer

Katherine R. McClure
University of South Florida Sarasota Manatee

Statistical modeling via the program R was utilized to determine the rate of correlation for a variety of factors with the incidence of liver cancer in Florida. All factors analyzed have previously been associated with liver cancer. Determination of which factors have the highest rate of correlation may be beneficial for future research. The factors evaluated were derived from the county health rankings website and include: adult obesity, binge drinking, low birthrate, adult smoking, physical inactivity, air pollution, low birth weight, and a lack of insurance. These were related to overall, female, male, Caucasian and African American liver cancer values using the Florida Cancer Systems statistical data. In this talk, we will discuss a study that focuses on the incidence of liver cancer in Florida and factors associated with it from 2011 to 2014.

3:00–3:15

A Machine Learning Approach to Where's Waldo

Chance Hamilton and Joshua Teeter

Florida Gulf Coast University

We explore how machine learning and image processing techniques can be combined to train a computer to play Where's Waldo. We utilize a trained Support Vector Machine (SVM) as a binary classifier and use Histograms of Oriented Gradients (HOG) as a feature descriptor. Our program, written in Python, has achieved a 100 percent success rate of finding Waldo with a few false positives.

3:20–3:35

Optimal Dimensionality for a Word Embedding Neural Network Model

Bi V. Nguyen

California State University, East Bay

Artificial neural networks are machine learning models mimicking the behavior of axons in a biological brain. Neurons are organized in layers, with weights between each layer that control how connected one neuron is to another. Neural networks are a supervised learning system, where inputs are fed into a system with known outputs. When inputs are entered into the network, the outputs will result in an error function, which is minimized via gradient descent. Neural networks are powerful modeling systems so that even a two layer networks can represent any bounded continuous function within an arbitrary degree of accuracy.In this project, we applied a neural network to a natural language processing problem. Specifically, we fed hundreds of thousands of text documents into a neural network in order to find synonyms for given glossaries. Our particular focus was to find the optimal embedding space dimension for the embedding space of the words.

3:40–3:55

Monte Carlo Simulation with Applications to Options Pricing

Duy Doan

Providence College

In financial mathematics, a European option provides the holder of the option the right to buy or sell an underlying asset at a fixed price (called the strike price) on a fixed date. This talk explains how these options can be priced based on the celebrated Black-Scholes model. The talk will also describe how the Monte Carlo method can be used in options pricing, and highlights some of its strengths and shortcomings.

Conference Room 4M **2:00P.M. – 3:55P.M.**

2:00–2:15

No Talk

2:20–2:35

No Talk

2:40–2:55

No Talk

3:00–3:15

Periodicity in Subtraction Games

Bret Benesh, Jamylle Carter, Deidra A. Coleman, Jack H. Good,
Michael A. Smith, Jennifer Travis, and Mark Daniel Ward
The College of St. Benedict/St. John's University, Diablo Valley College, Philander Smith College, Purdue University, Lone Star College-North Harris

We use data driven analysis to make conjectures about the periodicity of the structure of nim, a two player subtraction game in the field of game theory. Specifically, we aim to classify and describe all games with subtraction sets of size three in full generality. The approach used is computationally intensive (building on a database consisting of several terabytes of data about the game) and utilizes tools of data science and visualization. We are working towards an understanding of the structure of the game from a data driven perspective in an effort to characterize the precise periodicities. This work is supported by NSF grant DSM #1246818.

3:20–3:35

Anti-Games on Steiner Triple Systems

Sophie Mancini and Jacob Van Hook
James Madison University and Penn State University

The card game SET can be turned into a two-player tic-tac-toe style game: All cards are laid out on a table, and two players alternate taking one card at a time. The winner is the first to hold a set in their hand. "Anti-SET" is a variation of this game in which the first player to hold a set loses the game. Previous researchers found a first-player winning strategy for Anti-SET and related games. In this talk, we generalize the game of Anti-SET to a larger category of combinatorial objects called Steiner Triple Systems (STSs). These well-studied objects share many of the key geometric features that determine the winning strategy for Anti-SET. We investigate winning strategies for these games using geometric and combinatorial properties of STSs. This research was conducted as part of the 2017 REU program at Grand Valley State University.

3:40–3:55

Conway's RATS Sequences

Nadia N. Rodriguez and Chun Kit Szeto
New York City College of Technology

John H. Conway's RATS game (reverse-add-then-sort) begins by applying the following procedure on a positive integer: take the positive integer and reverse its digits, add the reversed number to the original, and reorder the digits in increasing order (discarding any zeros). The game ends if the sequence generated by iterating the RATS procedure ever repeats itself. The goal of this project is to study the statistical behavior of such sequences in various bases.

Conference Room 4Q **2:00P.M. – 3:55P.M.**

2:00–2:15

No Talk

2:20–2:35

No Talk

2:40–2:55

No Talk

3:00–3:15

A Magic Triangle: A Triangular Array of Positive Consecutive Integer Summations

David Shane
Methodist University

Our recent research on the relationship between positive consecutive integer summations and prime numbers has led to the construction of a triangular array (OEIS A049777) that consists of positive consecutive integer summation series. OEIS A049777 is a numeric arrangement that contains a plethora of relationships and geometric patterns which are reminiscent of the curiosities found in Pascal's Triangle. In this installment, we demonstrate the construction of this array through triangular numbers and develop a coordinate system for numeric location. We then proceed to explore several patterns in OEIS A049777, noting that this structure supports formulas from analytical geometry (in particular, the centroid of right triangles, squares, and hexagons) and places numbers in a hyperbolic arrangement. A method using positive consecutive integer summations is then presented in order to find the set of all locations for an arbitrary number, to test for primality, and to find the lattice points for a hyperbola. Keywords: elementary number theory, triangular arrays, triangular numbers, prime numbers, algebra, positive consecutive integer summations.

3:20–3:35

An Algebraic Sum of Divisors Function and its Applications

Carter Smith
University of Texas at Austin

A number n is called divisor of a number m if m divided by n leaves a remainder of zero. The sum of divisors function, which takes integers as inputs, arises repeatedly in elementary number theory. Its properties are often of interest along with those of a similar function, the sum of the kth powers of divisors function. This research sets out to study the injectivity of the sum of the kth powers of divisors function, compute counterexamples to its injectivity, and investigate further generalizations of the function. This process involves methods including the implementation of routines in Magma and Python as well as creating an equivalence relation on the set of Gaussian Integers which can be extended to any abstract integer ring.

3:40–3:55

Understanding Elliptic Curves in the Cryptographic World

Michael Holmblad
Winona State University

Elliptic curves are an intricate subject in the field of mathematics. They have their own group properties, and ways they interact with finite fields. When they are acting in a finite field they are classified as either strong or weak. We care about the curves in use today, and the curves that need testing. We will then be studying the intricacies of how we can randomly select a strong curve every time. Of course, we are most interested in curves that can form in the prime integer field because they are the easiest to work with and strongest numbers available to us. Since this is a project that deals with cryptography, we will also be looking at several cryptographic algorithms and applications that involve elliptic curves. Thus, we will be looking at elliptic curves in both a private key cryptography perspective and a public key cryptography perspective. It turns out that elliptic curve cryptography is a very controversial and actually the most popular form of cryptography as of late, and it is often paired with a symmetric key system within it. Therefore, we must analyze real world problems that elliptic curves have faced, and the many successes that they have had.

Lake Ontario **4:00P.M. – 6:15P.M.**

4:00–4:15

Exploring Blood Flow Dynamics Underlying Pathogenesis of Splenic Artery Aneurysms

Kirsten Giesbrecht
Centre College

If an expectant mother develops a splenic artery aneurysm that ruptures, there is a 90 percent fetal mortality rate. Splenic artery aneurysms account for 46-60 percent of visceral aneurysms in the human abdomen. The cause for the propensity of aneurysms to develop and rupture along the splenic artery is unknown. A distinguishing characteristic of this artery is its tortuous shape. We investigate how the unique geometries of the artery may lead to unusual patterns in blood flow. Dramatic changes in blood flow properties such as blood pressure, velocity and wall shear are conducive for aneurysm formation, development, and rupture. Using ANSYS Fluent computational fluid dynamics software, the influence of these elements of blood flow through both straight and curved arteries is explored. Additionally, blood flow changes associated with pregnancy are studied to identify causes for the ruptures of splenic artery aneurysms in pregnant women.

4:20–4:35

Sparse Signal Recovery Methods for Variant Detection in Next-Generation Sequencing Data

Andrew Fujikawa, Jonathan Sahagun, Katharine Sanderson,
Melissa Spence, Roummel Marcia, and Suzanne Sindi,
CSU Sacramento, CSU Los Angeles, Montana State University, UC Davis, UC Merced

Recent research suggests an overwhelming proportion of humans have structural variants (SVs): rearrangements of the genome such as inversions, insertions, deletions and duplications. The common methods of SV detection involve sequencing fragments from an unknown genome, mapping them to a reference genome, and analyzing the resulting configuration of fragments for evidence of rearrangements. While SVs occur relatively infrequently in the human genome, they are hard to identify due to the indirect nature of SV detection, resulting in high false-positive identification rates.¡br /¿Our approach aims to improve SV detection in two ways. First, we solve a constrained optimization equation consisting of a negative Poisson log-likelihood objective function with an attached penalty term that promotes sparsity. Second, we focus on detecting SVs in the analysis of multiple related individuals simultaneously. Therefore we are able to implement familial constraints, which limit a child's genome to express SVs if, and only if, one or more of its parents have first expressed a SV. This problem formulation is designed to improve SV detection despite a large amount of error attributed to both current DNA sequencing methods and noisy mapping processes from the test genome to the reference genome. Through careful modeling and leveraging related individuals to narrow the boundaries of study, we anticipate higher accuracy of SV predictions.

4:40–4:55

Modeling the Relationship Between White-Tailed Deer and Deer Ticks

Abigail Genereau
College of St Benedict

Tick-borne disease cases have been on the rise over the past decade, primarily Lymes disease.I researched the relationship between the populations of Deer ticks (lxodes scapularis) and White-tailed deer. Lymes disease cases have increased to about 320 percent since 1975 when it was discovered (Basu, 2015). To try to understand this drastic increase from a mathematical perspective, I researched the relationship between Deer tick (lxodes Scapularis) and White-tailed deer populations, using a mathematical model. White-tailed deer are the primary host of adult lxodes scapularis, the reproductive stage of the tick lifecycle (University of Florida). With a greater understanding of how deer populations affect the growth rate of Deer tick populations, we will be able to better understand how to manage both for the lowering of tick born disease rates.

5:00–5:15

Modeling Cilia-Driven Pulmonary Fluid Flow

Zack Miller and Mary Lib Saine
Furman University

Pulmonary cilia are flexible, densely packed, hair-like fibers that move with a coordinated whip-like motion in to propel contaminants out of the lungs. The pulmonary cilia form a carpet on the surface of the lung and the bulk effect of the cilia's coordinated motion is a metachronal wave that travels along the carpets surface. This wave helps propel the water-like periciliary liquid and the contaminants trapped in the adjacent mucus layer above it out of the lungs. We use the Method of Regularized Stokeslets to model the quasi-steady Stokes fluid flow generated by the immersed cilia. To model the cell surface that serves as a base for the cilia, we implement a system of regularized image singularities whose net effect creates a zero-velocity plane, replicating the cell surface. The dense spacing of pulmonary cilia creates modeling challenges. We investigate the fluid velocities in relation to the metachronal wave direction and the direction of the cilias effective stroke to increase understanding of this biological transport mechanism.

5:20–5:35

Using Graphs to Assemble DNA Fragments

Mukadder Cinar and Shrijana Ghimire
New York City College of Technology, CUNY

The DNA sequence assembly is a process in which DNA fragments are aligned and merged into a longer DNA sequence. The goal is to reconstruct the original sequence with a small error. We will discuss how graph theory can be used in this process. We will introduce the de Bruijn graph and show how the Eulerian circuits in these graphs can lead to the whole sequence with some error. The number of Eulerian circuits determines the probability of constructing the original strand of DNA based on a collection of fragments. The probability we will present depends on the number of certain spanning trees in a de Bruijn graph. This work is supported by an MSEIP Grant from the Department of Education. This is joint work with Rabea Begum.

5:40–5:55

Long-Term Behavior of Two Competing Populations on a Discrete Periodic Habitat

Camille Hankel
Georgetown University

We model a discrete periodic habitat in which two types of the same species compete. Using numerical simulations, we find that the two populations can reach three possible long-term outcomes as we vary the length of one of the environments in the periodic habitat: traveling wave, pinning, and extinction. As the length of one of the environments increases, the weaker competitor of the two populations first experiences a traveling wave, then experiences pinning, then switches between pinning and going extinct depending on where the initial population falls on the periodic habitat, and depending on the standard deviation of the Gaussian curve we approximate for our dispersal kernel. Our model offers new results not seen in a two-island model because the factor of length in our habitat allows the initial position of the population to affect the outcome.

6:00–6:15

Improving Automated Methods for Cell Identification in Calcium Images

Cara M. Nix and Meraiah Martinez
Univeristy of Minnesota- Twin Cities, Benedictine College, Michigan State University

New optical imaging technologies have the potential to revolutionize neuroscience, but are hindered by inaccurate automated cell identification. We are comparing results from current automated cell-sorting methods to careful human judgement. We are investigating the current algorithms which use singular value decomposition and non-negative matrix factorization. We are calculating single pixel statistics which are aiding our efforts to improve the automated methods in identifying neurons. We are exploring the correlations within the background noise of multiple neurons to augment our ability to identify, and then remove, the unnecessary background noise.

Lake Erie **4:00P.M. – 6:15P.M.**

4:00–4:15

Antarctic Subglacial Lake Detection Via a Discrete State-Switching Stochastic Volatility Model

Alyssa D. Jones
The University of Texas at Austin

Discovering subglacial lakes is a crucial part of modeling ice melt speed and is consequently vital for the accuracy of downstream tasks in climate modeling. Current practice is to have experts manually analyze radar data and make educated guesses about both the presence of subglacial lakes and the lake boundary points. We present a hierarchical Bayesian model of the underlying basal reflectivity that probabilistically detects the presence or absence of subglacial lakes. We show that radar reflectivity volatility maps well to a discrete-state switching AR(1) process and observe that subglacial lakes present as areas of substantially lower innovation variance in comparison to grounded ice. To the best of our knowledge our approach represents the first principled statistical method for subglacial lake detection in aerial ice-penetrating radargrams.

4:20–4:35

Statistical Programming in the Pharmaceutical Industry

Sally Dufek, Alyssa Farmer, and Joseph Hastings
Northern Kentucky University

Bringing a new drug to market requires conducting rigorous clinical trials and gaining approval by the Food and Drug Administration (FDA). This process includes testing the drug for both safety and efficacy and then restructuring the collected data into a standardized form for submission to the FDA. Beginning in 2016, clinical trial data is required to be submitted according to guidelines created by the Clinical Data Interchange Standards Consortium. Working with Medpace, a contract research organization, this project entails the standardization of data collected during a clinical trial for the development of a weight-loss drug.

4:40–4:55

Modeling Relationship Function in Social Networks

Alexander Black
Hamilton College

Social network models are commonly explored in modern mathematics, but few take into account the degree of functionality, with functionality defined colloquially as how well the relationships work, within such a network. We use a generalization of Adams' Equity Theory from social psychology to generate a model for that functionality. Based on the assumptions used in that generalization, we represent a social network as a weighted, directed graph with an associated stochastic adjacency matrix. From that representation, we define a network as functional if it may be represented by a symmetric stochastic matrix. Finally, to explore the results of that representation, we run a neural network that takes as input an anti-symmetric stochastic matrix and outputs a symmetric stochastic matrix to simulate the chaotic evolution of the relationship function in social networks.

5:00–5:15

A Hybrid Algorithm with Back-Propagation and Ant Colony Training for Neural Network

Michelle C. Xu

Arnold Beckman High School

Traditional back-propagation training for the feed-forward neural network may suffer from slow training issue, even with adjustable learning rate as well as momentum methods implemented. In this work, we applied a swarm intelligent algorithm, the ant colony optimization, to accelerate the training whenever a sign of slow training is detected.

5:20–5:35

Machine Learning Approach for the Prediction of Dissolved Oxygen Concentration

Cassia Smith

University of the Virgin Islands

Dissolved oxygen (DO) is essential to many forms of life in aquatic ecosystems as most living organisms require oxygen for their basic metabolic processes. DO concentration is one of the main indicators used in assessing water quality and the health of an aquatic environment. This project seeks to construct an accurate model for predicting DO concentrations in a lagoon area within Brewers Bay, St. Thomas VI and also to explore the influences on DO fluctuations. The ability to forecast oxygen (O2) levels will be invaluable in monitoring the health of local marine areas and analyzing the effect of bio phenomenon and human interference on those areas. Similarly, the model will also be useful for future research that might investigate any correlation between animal behavior patterns and oxygen concentration. A machine learning approach via MATLAB software will enable the development of several types of regression models. Though research is still ongoing, it has been possible so far to develop meaningful stepwise linear regression and decision tree models. Preliminary results have indicated the influence of several statistically significant predictors (air/water temperature, wind speed, etc.) on DO. Once a highly accurate model is developed, we can apply the working model to other oceanic regions.

5:40–5:55

Search for Nearest Correlation Matrix to Enable Monte Carlo Methods of VaR Assessments

Holly Caldes, Giancarlo Labruna, Katherine Ruddy, Harold Maria
Montclair State University

In the finance industry, the maximum amount of investment or capital that any firm has the potential to lose is of great interest to risk analysts. Value at Risk is one of the most widely used tests [to come up with] these future losses, and Monte Carlo simulations may be applied in VaR calculations. Historical time series of various financial market factors are used to simulate potential scenarios of investment outcomes for Monte Carlo purposes. However, these datasets are often inconsistent and cannot be easily analyzed. For example, they must be of a particular form in order for complex mathematical processes involved in Monte Carlo simulations to be performed. Namely, the property of positive definiteness makes correlation matrices analyzable. We represent a sample scenario of historical market inputs as a correlation matrix of U.S. daily stock returns, and then test such a matrix for positive definiteness. Many correlation matrices fail this test of positive definiteness, so we need to find the nearest possible matrix which is positive definite whenever the sample matrix does not have this property [at the outset]. This process involves theoretical developments drawn from linear algebra. We perform a spectral decomposition of the original correlation matrix and then undertake a nearest matrix search through a Python-based algorithm. The programming environment Python plays an important role in collecting market data, testing for positive definiteness, and implementing algorithms. When the closest possible matrix is calculated, it may be used for Monte Carlo simulations that will produce accurate predictions of maximal investment loss.

6:00–6:15

No Talk

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

4:00–4:15

Rendezvous Search on the Edges of Platonic Solids

Elanor West, Annie Xie, and Anan Zhang
Johns Hopkins University

The classic Rendezvous Search problem involves two players moving along the same line at random until they meet. We were inspired by the Astronaut Problem rendition in which two players are on a sphere moving at random until they meet. We have simplified the model to discrete units of time and to take place along the edges of platonic solids. The game rules we have used dictate that the game ends when the two players can "see" each other. We have compared the mean times for the game to end on all five solids, and have altered rules in various versions of the game to see how certain rules affect the mean time to end. Some variations we have tried are: simultaneous versus sequential versions, varying lines of "sight," and additional steps. Most of these variations we have explored on either the dodecahedron, icosahedron, or both, since they are closer approximations to a sphere than the octahedron, cube, or tetrahedron.

4:20–4:35

Symmetric Rendezvous on the Unit Cube

Jeffrey A. Braun and Jack Holmes
Johns Hopkins University

A famous open problem in the field of Search Games and Rendezvous is that of the Astronaut Problem. In an effort to develop new strategies and tools to make progress on the Astronaut Problem, we postulated a new, similar scenario that is interesting in its own right. Given two indistinguishable agents randomly placed on the surface of a cube who move at unit speed, their location on the cube defines their vision in the following manner: If they are on a face they can see the entirety of the face (including the edges and vertices that comprise it) and if they are on an edge or a vertex, it is as if they are on the two or three faces simultaneously that join together to make the edge or vertex. The goal remains unchanged from the Astronaut Problem: to determine which player-symmetric strategy minimizes the expected meeting time and what that value is. We have defined a strategy space which dominates among a large subset of all possible strategies. Within this strategy space, we closely examine some special cases. Our goals are to find the optimal strategy within our defined strategy space, derive accurate bounds for the smallest expected meeting time among all strategies, and to compare the strategy space to all strategies in general.

4:40–4:55

The Mathematics of Poker: Adaptive Strategies

Blandon Su, Fan Wu, Sultan Muratov, and Ruoyu Zhu

University of Illinois at Urbana-Champaign, Nazarbayev University

Poker games are perfect natural experiments of how people compete in a zero-sum game with imperfect information, gather information about their opponent's strategy, and adjust their own strategy accordingly. We investigate extensions and variations of classical poker models due to John von Neumann and others and seek to answer the question of how players should alter their strategies in a multi-round game, based on information from previous rounds of the game. Focusing on some specific extensions of the von Neumann model, we utilize minimax methods to determine the optimal strategy for the first player. With the technique of "level-k modeling" in game theory, we then explore how players develop adaptive strategies as they accumulate more information. Furthermore, we simulate how different strategies interact in real poker games based on our theoretical results, and visualize these simulations using Mathematica.

5:00–5:15

The Mathematics of Poker: Skill vs. Luck

Xinying Fang and Sara Rat

University of Illinois at Urbana-Champaign, Nazarbayev University

Is Poker a game mostly based on skill or is it a type of gambling that is prohibited by many states? Motivated by this long-lasting debate, we consider John von Neumann's classical poker model and its subsequent generalizations by others including noted economists and professional poker players. We classify players according to their skill levels and seek to quantify the relative effects and profit returns of skill and chance to determine which factor dominates in each poker model. Using game theoretic methods and Mathematica simulations and visualizations, we determine the long-time behavior of the profits for different levels of skill and different poker models.

5:20–5:35

Analyzing Small World Networks Using Persistent Homology

Jesus Sambrine

Kent State University

Introduce a small world network and develop a model. Varying a friction and the average path length parameters to observe the behavior of the system. The method of persistent homology is then used to study the system and observe the homological characteristic of the system during the Hopf bifurcation.

5:40–5:55

Efficient and Perfect Domination on Archimedean Lattices

Yunfan Zhao and Thomas Marge
Johns Hopkins University

For any graph G=(V,E), a vertex dominates itself and its neighbors. A dominating set S is a subset of V such that any vertex not in S is adjacent to at least one vertex in S. A dominating set S is an ecient dominating set if each vertex in G is dominated by exactly one vertex in S. Archimedean lattices are vertex-transitive innite graphs formed by regular polygons. Among all 11 Archimedean lattices, only 7 lattices are eciently dominable. For lattices that are eciently dominable, we demonstrate a method to eciently dominate them; for lattices that are not eciently dominable, we provide a proof. A dominating set S is a perfect dominating set if each vertex in V S is dominated by exactly one vertex in S. We also study the perfect domination on some Archimedean lattices.

6:00–6:15

Properties and Rigorous Bounding Methods of Minimal Domination Ratios on Infinite Graphs

Thomas G. Marge and Yunfan Zhao
Johns Hopkins University

A set S is said to dominate a graph G=(V,E) if every vertex in V is either in set S or is adjacent to a vertex in set S. T is a minimal dominating set if it dominates G and has a cardinality less than or equal to every other dominating set of G. For finite graphs, the minimal domination ratio of G=$\frac{|T|}{|V|}$. This problem can be solved as an integer program, and the dual of this integer program has a powerful interpretation. A graph is perfectly dominated by a set V if every vertex is dominated by exactly one vertex in V, including itself. Consider any infinite graph G composed of replicable subgraphs. G can be embedded in a x-y plane such that each unit square with integer boundaries contains exactly one replicable subgraph. Say each replicable subgraph contains k vertices. For any positive integer a,b,m,n, let R((a,b),(m,n)) denote the rectangular region of the infinite graph satisfying $a \leq x < m, b \leq y < n$. Let D_{mn} denote the cardinality of the minimum dominating set for R((-m,-n),(m,n)). Then $\frac{D_{mn}}{4mnk} \to \lambda$ as m,n $\to \infty$, where λ is the infinite domination ratio. Integer programming can be used to find upper and lower bounds on the infinite domination ratio for G. Additionally, some properties of finite domination ratios can be extended to the infinite case.

Conference Room 4Q **4:00P.M. – 6:15P.M.**

4:00–4:15

Quantum Jacobi Forms

Michael Barnett, Obinna Ukogu, Jack Wesley, and Hui Xu
Amherst College

Quantum Jacobi forms are a newly defined type of modular object in Number Theory: they are a natural hybrid of Zagier's quantum modular forms defined in 2010, and Jacobi forms, the theory of which was developed in the 1980s by Eichler and Zagier. There has been much research in these areas recently; in particular, their connections to mock modular forms and mock theta functions have been of great interest. In this talk, we will discuss certain analytic properties of quantum Jacobi forms, and offer some new examples and applications. In particular, we will investigate special values of these and related functions on boundary of the unit disk, which a priori contains numerous singularities.

4:20–4:35

The Luckiest Abelian Group: Examining the Error Term of Cohen-Lenstra Heuristics

Benjamin Doyle and Alex Eastwood
Ferris State University

This project explores the class number problem, a conjecture of Gauss that relates to the property of unique factorization. Every integer can be factored uniquely into primes (up to order and sign), and this property extends to some larger number systems as well. For example, the Gaussian integers (complex numbers with integer components) also have the unique factorization property. The extent to which a number system fails to have unique factorization is measured by an abelian group called the ideal class group; the larger the group, the farther the number system is from having unique factorization. In rough terms, Gauss conjectured that the size of these groups tends to infinity as we take more and more "complicated" number systems (specifically, this refers to imaginary quadratic extensions). One of the main tools for studying class numbers is the Cohen-Lenstra heuristics, which give an asymptotic prediction of how frequently each abelian group will arise as a class group. In this talk, we provide a brief overview of the history of the class number problem. We give concrete examples of the relationship between class group and factorization. Finally, we outline our algorithm and reveal the "luckiest" and "unluckiest" abelian groups relative to the Cohen-Lenstra prediction.

4:40–4:55

Ulam Sequences

Joshua Hinman, Borys Kuca, and Alexander Schlesinger
Yale University

An Ulam sequence is a sequence of integers such that each term is the smallest integer that can be written uniquely as a sum of two preceding terms. One can consider the distribution of this sequence taken modulo some fixed real parameter. Naively, one might expect this distribution to be uniform, but it is anything but. There is a clear and unexplained signal hiding in the Ulam sequence. We will give some generalizations of the Ulam sequence, and give some further examples of the odd structure of such problems.

5:00–5:15

On Carmichael's Totient Function Conjecture

Luke Szramowski
Slippery Rock University

On Carmichael's Totient Function Conjecture In 1907, Dr. Robert Carmichael posed the following question: For each $m \in \mathbb{N}$, does there exist an $n \in \mathbb{N}$, such that $m \neq n$ yet $\phi(m) = \phi(n)$? This question became known as the Carmichael Totient Function Conjecture, and has remained an open problem in number theory. In this talk, we will consider some of the different types of natural numbers that satisfy the Carmichael Totient Function Conjecture. What do their prime factorizations look like? And if a counterexample does exist, what properties would the counterexample have to have?

5:20–5:35

Extending the Diophantine Property to Functions

Rei Doko
Michigan State University

A Diophantine m-tuple is a set of m integers where the product of any two distinct elements in the set added by 1 is a perfect square. There are sets of functions which also satisfy the Diophantine property: for example $(x; x+2; 4x+4)$ is a Diophantine triple. In this talk we characterize m-tuple functions that satisfy the Diophantine property. We will also present several generalizations.

5:40–5:55

Sums of k-th Powers in p-adic Rings

Maia Hanlon, Tim Banks, Lucas Anthony, Angel Tuong, Chung Truong
McDaniel College

Generalization of Waring's Problem - that for every natural number k there exists an integer $g(k)$ such that every natural number can be written as the sum of at most $g(k)$ k-th powers - have been studied in a variety of contexts from algebraic number fields to non-commutative groups. We will examine values of $g(k)$ for various p-adic rings and extensions.

6:00–6:15

No Talk

Lake Ontario **8:30A.M. – 11:45A.M.**

8:30–8:45

No Talk

8:50–9:05

No Talk

9:10–9:25

Pair Correlations in Uniform Countable Sets

Sanjay A. Raman and Carl B. Schildkraut
Lakeside School, Seattle

We determine the pair correlations of countable sets $T \subset \mathbb{R}^n$. satisfying natural equidistribution conditions. The pair correlations are computed as the volume of a certain region in $\mathbb{R}^{2n}$, which can be expressed in terms of the incomplete Beta function. For $n = 2$ and $n = 3$ we give closed form expressions, and we obtain an expression in the $n \to \infty$ limit. We also verify that sets of lattice points and primitive lattice points satisfy the required distribution criteria.

9:30–9:45

Mathematical Analysis of the Effects of Age, Education, and APOE-4 Gene on Human Cognitive Function

Emily H. Dorn, Philip J. Grossweiler, and Savannah V. Swiatlowski
Olivet College, University of Texas- Rio Grande Valley, Central Michigan University

Extensive research has been conducted on Alzheimer's Disease and other forms of Dementia, yet much remains to be understood. A common quantitative measure of cognitive impairment in patients with Dementia is their score on the thirty-point questionnaire called the Mini-Mental State Examination (MMSE). For the initial study, we will investigate the relationship between MMSE scores and three factors known to have an effect on the rate of cognitive decline: age, years of formal education, and the APOE-4 gene. Other factors may be incorporated into the model in a future study. Using MATLAB and data from the National Alzheimer's Coordinating Center (NACC), our main goal is to develop an age-dependent differential equation model that will incorporate these factors:

$$\frac{\partial M}{\partial a} + k_1 \frac{\partial M}{\partial e} = k_2$$

where a denotes age, e denotes education, M denotes MMSE score, and k_1 and k_2 are constants. We hope to use this differential equation model to improve the understanding of how these factors work collectively to affect the degeneration of cognitive function in patients with Alzheimer's Disease and other Dementia disorders.

9:50–10:05

Modeling the Population of Common Carp in Big Green Lake

Antony Gradillas, Mitra Kermani, and Andrea Young
Ripon College

Common carp is an aquatic invasive species that is known to be harmful to local environments. The common carp population in Big Green Lake, WI has decimated several shallow water estuaries which has led to a deterioration of Big Green Lake. In this talk, we will discuss a model of the carp population using discrete-time metered models. The goal of this project is to understand the dynamics of the carp population and to provide recommendations for carp management strategies within Big Green Lake and surrounding estuaries.

10:10–10:25

Oscillations in Michaelis-Menten Systems

Hwai-Ray Tung
Brown University

A question of particular interest in cellular biology is to check whether there exist oscillations, or periodic solutions, in a given system. One of the best known approaches to evaluating the dynamics of a system is Michaelis-Menten (MM) approximation. However, this approach has some drawbacks; although Suwanmajo and Krishnan have shown the existence of oscillations in the dual futile cycle, a generalized MM system, Wang and Sontag proved that the MM approximation of the dual futile cycle has no oscillations. This talk will discuss the existence of oscillations in a related generalized MM system.

10:30–10:45

Modeling Biological Invasion with the Reaction-diffusion Equation

Shayna Bennett, Roberto Bertolini, Alyssa Fortier, Jessica Linton,
Patricia Roberts, Shilpa Khatri, and Karin Leiderman
*Johnson State College, University of Rochester, University of Arizona, Benedictine College,
CUNY Medgar Evers College, University of California, Merced, Colorado School of Mines*

Every year, invasive species cause irreversible damage to economies and ecosystems worldwide. Preventing the spread of such species is an important step toward reducing impact on native flora and fauna, along with preserving local economies. A noteworthy example is Japanese knotweed, Fallopia japonica, a perennial native to Eastern Asia. It was introduced to the United States in the 1870s as an ornamental plant and has since displaced native vegetation and clogged rivers. Since fragments from the main plant can generate new sprouts, transport of such fragments by river networks may play a key role in its spread. To better understand the impact of a river on the spread of Japanese knotweed, we applied the Crank-Nicolson time splitting method to a reaction-diffusion model and compared our results with field data to assess its accuracy.

10:50–11:05

Droning on about Sand Dunes and Machine Learning

Keri Haddrill

Hope College

Gusty winds expand across the dunes and send sand flying everywhere. They brush past the vegetation grasping at the sand, and together they alter the formation of dunes. The Saugatuck Harbor Natural Area (SHNA) along Lake Michigan has numerous open sand dunes at risk for extinction. Thus, our project's goal is to map the changes of vegetation over time. The first step in mapping SHNA is comparing the surface reflectance images collected by a drone and field biomass measurements from a few small selected areas. This information allows us to create a convolutional neural network that can approximate above-ground biomass and therefore produce a biomass map for the entirety of SHNA.

11:10–11:25

The Effect of Sea Surface Temperature on Seabird Behavior and Population Dynamics

Ben MacDonald, Mykhaylo Malakhov, and Shandelle M. Henson

University of Vermont, Andrews University

High sea surface temperatures (SSTs) in the Pacific Northwest of the US and Canada are associated with low food resources and behavioral changes in seabirds. Higher SSTs lead to an increase of egg cannibalism in gulls, which in turn promotes every-other-day egg-laying synchrony in the colony. We use a simplified discrete-time model to study population dynamics both within and between breeding seasons, allowing us to examine the possible long-term dynamic consequences and tipping points for the population as a function of SST. This research was conducted during a 2017 REU run by Andrews University.

11:30–11:45

Mathematical Modeling of the Spatio-Temporal Dynamics of Migratory Species

Sadie C. Piatt

Emmanuel College

Understanding the influence of specific habitats on the survival of a migratory species is an essential part of making successful conservation and management decisions. Migration is a complicated process, and mathematical models of migratory networks offer a way to understand the importance of different parts of an organism's annual cycle. Representing the system as a graph in which habitats are nodes and migratory paths are edges, the reproduction, survival, and movement of the population are modeled with time- and density-dependent functions. Under this network framework, we assess the importance of each node to the viability of the species by calculating two values: the C-metric and K-metric. The C-metric estimates the per-capita contribution of cohorts using a given node. The K-metric estimates the overall growth rate in the absence of a given node. We also investigate the effect of changes to the network by performing a perturbation analysis of our nonlinear model. Matrix calculus is used to derive the sensitivity of equilibrium population size to changes in parameters such as node and edge survival, and reproduction rate. We demonstrate how the proposed node metrics and sensitivities can be used to analyze a variety of hypothetical migratory networks of four habitats and two seasons.

Lake Erie **8:30A.M. – 11:45A.M.**

8:30–8:45

No Talk

8:50–9:05

No Talk

9:10–9:25

Investigating the Effectiveness of an Original Activity on the Mean Value Theorem

Beth Rawlins

University of Central Oklahoma

I will discuss my design and implementation of a tactile activity on the Mean Value Theorem. A pre-test and a post-test were administered to a control group and an intervention group consisting of Calculus 1 students. The data collected from these tests was analyzed to assess the effectiveness of the activity. Additional remarks will include my reflection on the intricacies of mathematics education research as well as my personal takeaways.

9:30–9:45

Student's Experiences in STEM Summer Camp

Devyn C. Rice

Texas A&M University

Gender, ethnicity, and SES differences have been shown to influence students interest in STEM careers. Diversity is vital in STEM fields because the best solutions are brought about through a broad range of ideas from a variety of individual backgrounds. The purpose of the present project is to examine how a two-week STEM Summer Camp affects students STEM interest in a student population made up of diverse middle and high school students. The teaching methodologies and strategies used in this camp engaged a diverse student population in STEM content through various innovative instructional practices (e.g., hands-on learning activities). The results of the pre- and post-tests (N = 129) showed an increased interest in STEM subjects and careers, as well as a reduction in the achievement gap due to ethnic and gender background differences. Informal STEM experiences may have the potential to increase interest in STEM fields and, in turn, promote diversity in the STEM workforce.

9:50–10:05

Math 167: Created by Students, Taught by Students, For the Students

Jonathan Gerhard, Haley Dewey, Aaron Fowlkes, Ian Hill,
Alison Sall, Cameron Stopak, and Nicole Sutherland
James Madison University

We describe a one-credit topics course in mathematics, designed and taught by undergraduate students at James Madison University. The course, which has just finished its fourth successful semester, introduces lower division students to exciting topics in mathematics while developing JMU's mathematical community.

10:10–10:25

Student-Initiated 3D Printing Project in Multivariable Calculus

Cody Burker
Franklin College of Indiana

One of the most challenging obstacles for students new to multivariable calculus is developing the ability to visualize three-dimensional graphs. Creating an activity to aid students in developing this through concrete means can accelerate the learning process. While in a multivariable calculus class, with the help of the professor, I created an assignment to help myself and my fellow students do just that. This assignment started with partners in the class being assigned different three-dimensional functions that resulted in familiar graphs. Then they followed a guide I created to digitally render this function to a file-format that is 3D printable. Finally, they began the process of 3D printing the function. By combining the abstract, and to new students foreign, nature of graphing in a third dimension and combining it with the engaging and tangible nature of 3D printing, the students were able to gain a more intuitive understanding of some of the underpinnings necessary for an introductory understanding of multivariable calculus. I was able to increase my understanding of how to teach a combination of technical, software-specific skills along with the connections this activity made to the conceptual skills. During my presentation, I will make available the assignment I created, either via physical copy or simply by email. Moving forward, I would create more post-printing activities in order to further cement the connections made by the students, and allow the students the opportunity to interface with more than simply one function.

10:30–10:45

Analysis of Students' Progress and Workshop Participation in a Peer-Led Team Learning Precalculus Course

Farjana Shati
New York City College of Technology

New York City College of Technology has adopted the Peer-Led Team Learning (PLTL) instructional model in a Precalculus course. A Peer Leader, usually an upper classman undergraduate, leads a group of 8-10 students through an active learning one hour a week workshop. Results from the study showed this pedagogical paradigm of active engagement to be effective in retaining and passing students in Precalculus. Factors examined in this study includes gender, ethnicity, self-efficacy, goal orientation, and workshop attendance.

10:50–11:05

Cameron's Method, Stimulating Students with an Alternative Way to Multiply

Justin Cameron
Southern Illinois University-Edwardsville

Often times, students struggle with the essentials of an everyday quests to add, subtract, multiply and divide upon completion of elementary mathematics operations. The most frequent examples occur in students from stigmatized minority groups, who sense (or who are told) that their intellectual abilities are viewed as inferior by authority figures, and many others. In this charged situation, vulnerable students and faculty often ask, "How do we reduce or eliminate such a stigma?" This presentation will offer an alternative way to multiply numerals that will assist 6th through 8th grade students in strengthen their addition, subtraction, multiplication and division skills as well as push students to recognize patterns/relationships of numbers.

11:10–11:25

A Geometrical Analysis of Harmony and Voice Leading in Music Using Quotient Orbifolds

Aditya Sivakumar
Beaverton High School

Western music is based on two concepts - harmony, which is the simultaneous sounding of multiple notes (chords), and voice leading, which is the motion of these notes (voices) through time. The incorporation of these two concepts is called counterpoint. Geometry and topology are powerful tools for studying counterpoint in music. A musical chord can be defined as an n-tuple in an n-dimensional non-Euclidean geometric quotient space called an orbifold. The location and characteristics of a chord in the orbifold is defined by symmetry as well as the consonance or dissonance of the chord. The voice leading from one chord to another within the orbifold is defined by vectors in the space. In this study, a new technique using quotient orbifolds has been developed to identify good sounding music and the limits of playability as a guide for efficiently composing music. Over 300,000 chord transitions were analyzed with a Python program and a random sample was graphed onto the orbifold. Some extremely interesting geometric properties of voice leadings were revealed visually for the first time and this innovative visual technique easily identified the ones that violated counterpoint rules or were unplayable. In conclusion, this study describes the development of a powerful new technique using orbifolds and assisted by computational methods to efficiently compose new music, and this should prove extremely useful to musicians and composers.

11:30–11:45

Euler's Tonnetz and Mary's Goat: Algorithmic Music Composition

Collin C. Smith
Cornell College

In the late eighteenth century, Mozart wrote a musical dice game. The "player" would roll the dice to order selected bars of music in sequence, randomly composing a new piece using precomposed excerpts. In writing this game, Mozart was trying his hand at algorithmic music composition. We can reduce music composition to a structured process, exploiting the rigid theory behind what makes tonal music pleasing. Many algorithmic composers explore this concept of formulaic music, while others prefer to avoid it. John Cage sought to free music of all structure, exploring indeterminacy of composition with pieces such as Music of Changes. This exploration considers the approaches of both Mozart and Cage, applying basic music theory to write algorithms for tonal or conventionally pleasing composition, while also using random elements to ensure a nontraditional sound.The first program discussed uses a Markov process. Using the relative frequencies of pitches and note durations in an existing melody, we generate Markov transition matrices which are used to randomly determine the pitches and rhythms of a new song with many of the same characteristics as the original. The second program uses the Tonnetz to generate the notes of a melody. This "tone network," first described by Leonhard Euler in 1739, arranges pitches according to their harmonic function. In other words, notes that are next to each other sound good when played together. This nontraditional arrangement of pitches, when used as a tool for stochastic music composition, produces odd melodies that still have music theoretical concepts behind their composition. All implementations use Java, and the jMusic programming library.

Lake Michigan **8:30A.M. – 11:45A.M.**

8:30–8:45

No Talk

8:50–9:05

No Talk

9:10–9:25

Radio Labeling of Square Cycles

Yazmin Estrada and Joel Salazar,
California State University San Bernardino

We are investigating optimal radio labelings of radio stations that avoid radio interference between them. We present this issue using graph theory, comprising a mathematical model where each vertex represents a station and the edges represent the closeness of the stations. Let G be a connected graph. The distance between two vertices u and v in G is defined by the length of the shortest path in G between u and v, which is denoted $d_G(u;v)$. The diameter of G, denoted by diam(G), is the maximum distance between two vertices in G. the radio labeling of G is a function f that assigns each vertex a non-negative integer such that $|f(u) - f(v)| \geq \text{diam}(G) - d_G(u;v) + 1$ holds for any two distinct vertices u and v of G. the span of f is the difference of the largest and smallest channels used. The radio number of G, denoted by $rn(G)$, is defined as the minimum span of all radio labelings of G. The function f is said to be an optimal radio labeling of G if span$f = rn(G)$. In this presentation, we will discuss the progress we made on the unsolved case for $rn(C_n^2)$ where $n = 4k + 3$ with $k = 4m + 3$ for some integer m.

9:30–9:45

Methods for Improving the Lower Bound of $R(5, 5)$

James A. Marshall Reber
Purdue University

We define a Ramsey number $v = R(m, n)$ to be the minimum number of vertices such that all graphs of order at least v will have either a clique of size m or an independent set of size n. Erdős was able to not only establish the fact that all Ramsey numbers are finite using the probabilistic method, but he established some rough bounds for these numbers. Over the years, these bounds have been improved tremendously using analytic and computational methods. In this presentation, I will focus on the computational methods used to improve the bounds for Ramsey numbers, which revolve around finding a counterexample to the Ramsey problem. More specifically I will be talking about the application of these methods to the problem of improving the lower bound of $R(5, 5)$, or the fifth Ramsey number. I will also talk a little about some conjectures that my group has on the structure of the counterexamples for symmetric Ramsey numbers, and how these may lead to improving the lower bound of $R(5, 5)$.

9:50–10:05

Randic Connectivity Indices for Decagonal Graphs

Kateryna Kaplun
Montclair State University

In this research project, we investigate graphs made of n regular decagons and their Randic Connectivity Index (RCI) values. These graphs, called decagonal graphs, come from biology and chemistry applications. We give an explicit formula for the RCI values of each decagonal graph without interior vertices called decagonal trees. The graphs with maximum or minimum RCI among all decagonal trees of n decagons are identified. We further show that a symmetric cycle of decagons must be of size 4, 5, or 10 and explicit formulas are given. In the most general case, we provide the explicit formula the RCI value of any decagonal graph. The graphs with maximum and minimum RCI for general decagonal graphs are given and are based on the number of bays, fissures, and hourglasses.

10:10–10:25

Monodromy Groups of Toroidal Graphs

Chineze Egbunike Christopher, Robert J. Dicks, Gina Marie Ferolito,
Joseph M. Sauder, and Danika Keala Van Niel
Purdue University, Emory University, Wellesley College,
Pontifical Catholic University of Puerto Rico, Syracuse University

A graph $\Gamma = (V, E)$ is a pair consisting of vertices V and edges E. Such a graph is said to be planar if it can be embedded $\Gamma \hookrightarrow S^2(\mathbb{R})$ on the sphere such that its edges do not cross. Similarly, such a graph is said to be toroidal if it can be embedded $\Gamma \hookrightarrow \mathbb{T}^2(\mathbb{R})$ on the torus such that its edges do not cross. This project seeks to determine the monodromy groups of such graphs.
In this talk, we discuss various examples of toroidal graphs, including the Utility Graph, Petersen Graph, and more generally 3-regular graphs. Given a particular embedding $\Gamma \hookrightarrow \mathbb{T}^2(\mathbb{R})$ of a graph with $N = |V|$ vertices, we can label the edges E to find a particular group $G = \text{im}\left[\pi_1\big(\mathbb{P}^1(\mathbb{C}) - \{0,\, 1,\, \infty\}\big) \to S_N\right]$ called the monodromy group; it is the "Galois closure" of the group of automorphisms of the graph. We will discuss some of the challenges of determining the structure of these groups, and present visualizations of group actions on the torus.
This work is part of PRiME (Purdue Research in Mathematics Experience).

10:30–10:45

Generators for Jacobians of Random Graphs

Ethan Sciamma, Henry Reichard, Yuxuan Ke, and David Brandfonbrenner
Yale University

The Jacobian of a finite graph is a finite abelian group that arises in combinatorics, arithmetic, and algebraic geometry, and is constructed from the combinatorial Laplacian of the graph. In recent years, the Jacobians of random graphs have been shown to exhibit a number of remarkable properties. For instance, the Jacobian of a random graph appears to be cyclic with probability approximately 0.79. In this talk, we consider a refinement of this question. The Jacobian of any graph comes with a collection of distinguished elements. We explore the probability that these distinguished elements generate the Jacobian.

10:50–11:05

On the Existence of Primitive Cycle Decompositions

Kira Owsley and Michael Schroeder
Marshall University

The decomposition of edges of a graph is a traditional area of research in graph theory. For a graph G with vertex set V and edge set E, a decomposition of G is a partition of E. Assume that E contains all possible edges connecting vertices in V, and let $\mathcal{C}$ be a decomposition of G. We say that $\mathcal{C}$ is non-primitive if there exists a nontrivial proper subset of vertices $V' \subset V$ and a proper subset of parts $\mathcal{C}' \subset \mathcal{C}$ such that $\mathcal{C}'$ is itself a decomposition of all edges connecting vertices in V'. In this paper, we investigate the existence of primitive cycle systems – primitive decompositions into cycles of a fixed length – where the cycle size is even. We show that K_9 – a graph on 9 vertices with all possible edges – and K_{21} have primitive 6-cycle systems, if K_n has a primitive 6-cycle system, then K_{n+12} also has a primitive 6-cycle system, and make other progress in proving if K_n has a primitive m-cycle system for m even, then K_{n+2m} has a primitive m-cycle system.

11:10–11:25

Homology of Permutation Complexes

Catherine A. Wallick
St. Catherine University

We form permutation complexes by inducing simplicial complexes upon the cliques of permutation graphs. To define a permutation graph of order n, we take a permutation $\pi \in S_n$, the group of permutations on vertex set $\{1, \ldots, n\}$ and create an edge between vertices $x < y$ if and only if $\pi^{-1}(y) < \pi^{-1}(x)$. That is, each inversion of the permutation corresponds to an edge of the graph. We then generate a simplicial complex from this graph by building a face from each complete subgraph. We show how the topological properties of the resulting structure are encoded within the permutation and give the precise permutation patterns that determine homological cycles of each dimension.

11:30–11:45

Predicting Separability from Partial Voter Preferences in Referendum Elections

Tasha Fu and David Shane
University of Maryland Baltimore County, Grand Valley State University

In referendum elections, voters are often required to cast simultaneous votes on multiple questions or proposals. The separability problem occurs when a voter's preferences on the outcome of one or more proposals depend on the predicted outcomes of other proposals. Preferences that are free from such interdependencies are said to be separable. Determining the extent to which a voter's preferences are separable often requires extensive information about their ranking of all of the possible election outcomes. In this talk, we will explore what conclusions about separability can be made from partial voter preferences. Our work has potential applications to election sequencing, particularly when only incomplete information about voter preferences is available. This research was completed as part of the Summer Mathematics REU at Grand Valley State University.

Conference Room 4M **8:30A.M. – 11:45A.M.**

8:30–8:45

Isoperimetry in the Hyperbolic Plane with Density

Alejandro Diaz
University of Maryland, College Park

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.

8:50–9:05

Isoperimetry in Surfaces with Densities

Nat Sothanaphan
Massachusetts Institute of Technology

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

9:10–9:25

Double Bubbles in Borell Space

Arjun Kakkar
Williams College

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 Borell Space, the Euclidean plane with density e^{r^2}.

9:30–9:45

Least-perimeter Tiles of Space

Eliot Bongiovanni
Michigan State University

We seek least-perimeter tiles of Euclidean space of unit volume. For example, despite what Aristotle said, the regular tetrahedron does not tile space; we seek to prove the optimal tetrahedral tile.

9:50–10:05

Equal Circle Packing on Flat Klein Bottles

Sean Haight and Quinn Minnich
Western Washington University and Millersville University

The study of maximally dense packings of disjoint equal circles is a problem in Discrete Geometry. The optimal densities and arrangements are known for packings of small numbers of equal circles into hard boundary containers, including squares, equilateral triangles and circles. In this presentation, we will explore packings of small numbers of equal circles onto a boundaryless container called a flat Klein bottle. Using numerous figures we will introduce all the basic concepts (including the notion of a flat Klein bottle, an optimal packing and the graph of a packing), illustrate some maximally dense arrangements, and outline the proofs of their optimality. This research was conducted as part of the 2017 REU program at Grand Valley State University.

10:10–10:25

The Maximum Volume of a Rectangular Prism Inscribed in a Tetrahedron

Timothy G. Mou
Illinois Mathematics and Science Academy

It is well known that the maximum area of a rectangle inscribed in a triangle is 1/2 of the area of the triangle. The three-dimensional analog would be a rectangular prism "inscribed" in a tetrahedron, meaning that the prism has one face that lies on a face of the tetrahedron. We obtained a formula for the maximum volume R of an inscribed rectangular prism in terms of the side lengths of the tetrahedron. We proved that R is at most $2V/9$, where V is the volume of the tetrahedron. We also obtained necessary and sufficient conditions for R to be equal to $2V/9$.

10:30–10:45

Probabilities Involving Standard Trirectangular Tetrahedral Dice Rolls

Rulon W. Olmstead and Don Eliezer Baize
BYU - Hawaii

Our objective is to model the probabilities of rolling standard tri-rectangular tetrahedral dice. We projected the vertices and edges of a tetrahedron onto the surface of a sphere centered at the center-of-mass of the tetrahedron. By calculating the surface areas bounded by the resultant geodesics, we achieved baseline probabilities. Using a 3D printer, we constructed dice of uniform density and recorded the results of rolling them. We found statistically significantly different confidence intervals for different methods of rolling the dice. Thus, we made conjectures and performed additional dice rolls for verification.

10:50–11:05

Complex Numbers, Ptolemy's Theorem, and the Law of Cosines

Karissa Palmer
South Dakota State University

The Law of Cosines is well known, but most students have not seen a proof of this result. This presentation will use geometric properties of complex numbers including the Triangle Inequality, with conditions determining when it becomes an equality, and prove Ptolemys Theorem concerning some properties of cocyclic quadrilaterals. Finally, Ptolemys Theorem will be utilized to prove the Law of Cosines.

11:10–11:25

Computational Assembly of Jigsaw Puzzles

Qimeng Yu and Peter Illig
Carleton College

"Turning and turning in the widening gyre, the falcon cannot hear the falconer; Things fall apart; the centre cannot hold; Mere anarchy is loosed upon the world..." - William B. Yeats. When things fall apart, who can put them back together? In this talk, we will present computational methods to reassemble blank jigsaw puzzles, relying on shape alone to determine assembly information. Using a measurement of shape known as an invariant signature, we discuss the process of finding matching puzzle pieces and algorithms for aggregating these matches into an assembled puzzle.

11:30–11:45

Mercator's Cylindrical Map Projection

Amanda Matson
Kent State University

Gerardus Mercator, a Flemish cartographer from the 16th century, presented what is now known as Mercator's Projection. This projection was obtained as Mercator displayed the Earth's curved surface on a plane. We are to analyze conformality–an essential characteristic of the cylindrical projection. This conformal property is defined by an equality of angles and a point scale factor that is independent of direction. Given that the meridians and parallels are orthogonal, Mercator's projection is commonly used for navigation especially near the equator. Due to the linear scale enlarging with latitude, the area of geographical objects progressively distorts nearer the poles. These distortions are explained best by utilizing Nicolas Tissot's idicatrix.

Conference Room 4Q **8:30A.M. – 11:45A.M.**

8:30–8:45

Signature Curves in Computer Vision

Robert Klemm, Annelia Anderson, and Lucas Tucker
University of Saint Thomas

The human brain can process visual information and identify objects effortlessly. The field of computer vision does not yet have the capability for object recognition to the extent that the human brain does. Creating this capability in computers is a challenging problem for mathematicians and computer scientists. In this project, we are introducing a mathematical method based on signature curves derived from differential geometry and topological skeletons. A signature curve of a closed 2-dimensional curve is created by plotting its curvature and together with the derivative of its curvature with respect to arc-length. A topological skeleton is a graph consisting of edges and nodes that are equidistant to a given shape's boundary. Skeletons are both geometric and topological in nature. Combing these two techniques together, we have created a method called the skeleton signature curve, which can give us a way of identifying objects and has various applications, including some in medical imaging.

8:50–9:05

Computer Experiments with Visualizations: from Butterflies to Animated Spiral Galaxies

Hashir Qureshi, Lei Zhang, Sandra Torres, Boyan Kostadinov
City Tech, CUNY, BMCC, CUNY,

We present several computer experiments designed to create complex visualizations, including a family of butterflies, art patterns created through contour projections superimposed with heat maps, and an animated visualization of two colliding spiral galaxies. These projects were a part of a 4-day summer coding camp for STEM majors and they were developed with the idea of mixing programming, mathematics and computer experimentation. The summer coding program and the work on these projects are supported by a MSEIP Grant from the US Department of Education #P120A140030.

9:10–9:25

An Extension of the Hypotenuse-Leg Theorem

Emma L. Fancher
University of North Alabama

Two triangles are considered to be congruent if and only if they have all three sides and all three angles congruent. There are several theorems in neutral geometry which allow us to conclude two triangles are congruent using only three pieces of information, such as Side Angle Side (SAS) and Angle Angle Side (AAS) among others. It is well known among geometry students that the relationship SSA, in which two sides and an angle not included between them are congruent, does not necessarily result in congruent triangles. There is, however, a congruence included in most textbooks known as the Hypotenuse-Leg Theorem (H-L) that states the following: if two right triangles have a leg and their hypotenuses congruent, then the two triangles will be congruent. This talk will discuss another case in which SSA does imply congruent triangles.

9:30–9:45

Weak Visibility Preserving Functions

Jack J. Billings and Neil Nicholson
North Central College

A point P in a set S of lattice points is weakly visible from the origin O if no other point in S lies on the line segment OP. A function whose domain is S with co-domain consisting of lattice points is said to be weak visibility preserving from O if any point P that is weakly visible from O in S, then $f(P)$ is weakly visible in $f(S)$. Two particular types of functions are investigated, with one always being weak visibility preserving and the other never being so.

9:50–10:05

Topology of Tropical Moduli Spaces of Curves

Alois Cerbu, Luke Peilen, and Andrew Salmon
Yale University

The tropical moduli spaces of pointed curves are parameter spaces for certain metric graphs, i.e. graphs with a notion of length for each edge. These parameter spaces are closely related to the outer automorphism groups of free groups and to the moduli space of curves, and allow these objects to be studied using combinatorics and topology. Motivated by analogous constructions in algebraic geometry, first studied by Hassett, we study the network of tropical moduli spaces of weighted stable curves and determine their homotopy types in a range of cases. This builds on recent work of Chan and Chan-Galatius-Payne.

10:10–10:25

The Sylvester-Gallai Theorem in Tropical Geometry

Milo Brandt, Catherine Lee, and Michelle Jones
Yale University

The Sylvester-Gallai theorem states that given a collection of non-collinear points in the plane, there must occur at least one line that passes through precisely two points. The statement dates back to the 19th century, and has a delicate interaction with the geometry of inflection points of a plane cubic curve. In the tropical plane, which might be thought of as a shadow of the complex plane, the behavior of lines and curves is more subtle. For instance, two tropical lines may intersect along a ray, while remaining distinct. We investigate the incidence geometry of lines in the tropical plane, focusing on the Sylvester-Gallai theorem and related geometries.

10:30–10:45

Crossing Fans of Segments Determined by a Finite Point Set

Brenna D. Peever
University of Idaho

Let S be a finite set of points in the plane in general position. We investigate the number of points S must contain in order to guarantee the existence of specified patterns of intersecting segments determined by S. Specifically we are interested in “fans” of segments sharing a single point of S in which each segment in the fan is crossed by a single segment or set of segments.

10:50–11:05

Automorphism Groups and Arrangements of 11 Lines

Baian Liu
Vassar College

A line arrangement is a collection of lines in some plane, and it can be studied using geometry, algebra, combinatorics, and topology. An (n_3) configuration is a line arrangement of n lines and n triple points, where each line contains exactly 3 triple points. Amram, Cohen, Teicher, and Ye found some arrangements with an interesting topological property in the list of 11 arrangements obtained by adding a tenth line through three doubles points in (9_3) configurations. Along with Cohen, we find that there are 322 arrangements up to isomorphism obtained by similarly adding an eleventh line to (10_3) configurations. This is proven complete using an algorithm and the automorphism groups of the (10_3) configurations. We analyze each arrangement in search of the same interesting topological property.

11:10–11:25

Geometry of Quartic Polynomials

Landon Gauthier
UW-Platteville

Given a complex-valued polynomials of the $p(z) = (z-1)(z-r_1)(z-r_2)^2$with $|r_1| = |r_2| = 1$, where are the critical points located? The Gauss-Lucas Theorem guarantees that the critical points of such a polynomial will lie within the unit disk. This talk (the result of an undergraduate research project) explores the location and structure of these critical points. For example, the unit disk contains two 'desert' regions, the open disk $\{z||z-3/4| < 1/4\}$ and the interior of $2x^4 - 3x^3 + x + 4x^(2y^2) - 3xy^2 + 2y^4 = 0$, in which critical points of such a polynomial cannot occur. Furthermore, each c inside the unit disk and outside of the two desert regions is the critical point of exactly two such polynomials.Special attention will be given to the development of geometric intuition and using GeoGebra to provide graphical illustrations.

11:30–11:45

Locally Linear Embedding of Chromatic Clusterings in Temporal and Spatial Domains

Linda Beverly
CSU East Bay

The capability to identify chromatic groupings within video is an important application of video processing. In this research we present an application of Locally Linear Embedding, a method of geometric dimensionality reduction, applied to identifying similar color regions over time within video. This technique preserves the underlying geometric information. Identifying similar regions of color can be used to preprocess information that may be used to prepare the information for edge detection, video compression, and psychovisual optimization.

Lake Ontario **2:00P.M. – 3:55P.M.**

2:00–2:15

No Talk

2:20–2:35

Irreducible Characters and Their Restrictions to Subgroups

Kempton Albee and Eric Roon
Metro State University

Representations are special functions on groups that give us a way to study abstract groups using matrices, which are often easier to understand. In particular, we are often interested in irreducible representations, which can be thought of as the "building blocks" of all representations. Much of the information about these representations can then be understood by instead looking at the trace of the matrices, which we call the character of the representation. This presentation will address restricting characters to subgroups by shrinking the domain of the original representation to just the subgroup. In particular, we will discuss the problem of determining when such restricted characters remain irreducible for certain low-rank classical groups.

2:40–2:55

The Relationship Between the Prime Ideals of a Local Ring and the Prime Ideals of its Completion

Timothy Kostolansky and Caitlyn Booms
Williams College, University of Notre Dame

Let R be a Noetherian ring with exactly one maximal ideal. We define a metric on R with respect to its maximal ideal, and then we define the completion of R with respect to the metric. The relationship between R and its completion is not well understood, and we present results showing that this relationship can have unexpected properties. In particular, we discuss chain conditions on prime ideals of R and its completion.

3:00–3:15

An Unexpected Relationship Between Rings and Their Completions

Alex Semendinger and Chloe Avery

Williams College, UCSB

Let R be a local ring and let T be the completion of R with respect to its maximal ideal. If R satisfies certain nice chain conditions on its prime ideals, such as being catenary, does T satisfy the same conditions? We present results toward answering this question.

3:20–3:35

Accidental Spin

Brad Horner

University of Nebraska at Omaha

Rotation groups have double covers Spin(n) in which 720 degrees of spinning is necessary to "return to normal"; 360 degrees is insufficient. This fact is usually illustrated with the belt/plate/string trick of Dirac. More generally there is a Spin(p, q) for p space dimensions and q time dimensions. When $p + q \leq 6$, a patchwork of "accidental isomorphisms" allow us to represent Spin(p, q) as classical groups over division algebras. Most treatments seem to be obscure, unsystematic or less-than-comprehensive, treating only the common ones and giving formulas lacking motivation and explanation; this project attempts to correct this, as well as generalize slightly using split division algebras.

3:40–3:55

Sums of k-th powers in Quaternion Rings

Chung Truong, Angel Tuong, Lucas Anthony, Maia Hanlon, and Tim Banks,

McDaniel College

Generalizations of Waring's Problem – that for every natural number k there exists an integer $g(k)$ such that every natural number can be written as the sum of at most $g(k)$ k-th powers – have been studied in a variety of contexts from algebraic number fields to non-commutative groups. We extend current results on $g(4)$ and $g(2)$ for certain Quaternion rings with integer coefficients.

Lake Erie **2:00P.M. – 3:55P.M.**

2:00–2:15

Spectrum and Eigenvectors of the Discrete Preisach Memory Model

Daniel Kim

Texas Academy of Mathematics and Science

The Preisach model is a well-known input-output model that was originally proposed for magnetic hysteresis, characterizing transitions between magnetic dipole states as a function of the system's previous states. This dependence of a system on its history of possible states has been extended beyond magnets to obtain suitable mathematical models for a variety of hysteresis phenomena in engineering, physics, and economics applications. Transitions between 2^N states of the discrete Preisach model can be described by a directed graph Γ. We consider an adjacency matrix A_N associated with a random walk on this graph. Alternatively, the same matrix is associated with the random evolution of an inventory under the "Last In, First Out" (LIFO) inventory management rule. By relating the self-similar nature of LIFO directed graphs to the recursive nature of Chebyshev polynomials, we are able to obtain explicit formulas for the spectrum and eigenvectors of the non-symmetric adjacency matrix A_N.

2:20–2:35

Analysis of the Limiting Speed of Excited Random Walks

Paige Schoonover, Jacob Menix, Joseph Jackson, Claire Plunkett, and Michael Cinkoske

University of Tennessee, Western Kentucky University, Swarthmore College,
Case Western Reserve University, Purdue University

Excited random walks are a generalization of the simple random walk model where the transition probabilities, instead of being the same for every step, are dependent on the number of prior visits to the current location. One interesting feature of excited random walks is that they can be transient to the right but with positive speed or zero asymptotic speed, depending on the specific parameters defining the excited random walk. A simple and explicit criterion has been proved which determines exactly when the limiting speed is positive, however, there is no explicit formula for the speed as a function of the parameters of the model. While the speed cannot be explicitly calculated, we are nonetheless able to study some properties of the speed function and give explicit upper and lower bounds on the speed in certain cases.

2:40–2:55

Excited Random Walks and Perturbed Brownian Motion

Claire Plunkett, Paige Schoonover, Jacob Menix, Joseph Jackson, and Michael Cinkoske
Case Western Reserve University, University of Tennessee, Western Kentucky University, Swarthmore College, Purdue University

Excited random walks are a generalization of the simple random walk model where the transition probabilities, instead of being the same for every step, are dependent on the number of prior visits to the current location. Excited random walks can exhibit quite different limiting behaviors than simple random walks. In particular, while simple symmetric random walks have Brownian motion as their scaling limit, it has been shown that excited random walks can converge instead to a process called a perturbed Brownian motion. We consider some examples of excited random walks where it is conjectured, but not yet proved, that the scaling limit is a perturbed Brownian motion. We do large scale simulations of the excited random walks and perform statistical analysis to test the conjecture that the scaling limit is a perturbed Brownian motion.

3:00–3:15

Mathematics of Magnetism: A Continuous Extension of the Ising Model

Jordan Weathersby and Nathan Fiege
Carthage College

The Ising model assumes a ferromagnetic material is made of discrete particles, but what happens if we instead assume it is continuous? In this talk we will derive a continuous model for magnetism, based on physical principles and energy arguments. This type of model has many mathematical advantages, including the possibility of explicitly calculating material properties, phase transitions, and the dynamics of the formation of magnetic domains. We will discuss preliminary results in several simple cases.

3:20–3:35

Decryption using Monte Carlo Markov Chains

Jeffrey Tumminia
New York City College of Technology

We use Monte Carlo simulations of a random walk in R to uncover the decryption function of an encrypted message. Using an approximated transition matrix of the characters in the English language and properties of Markov Chains, we develop a method for evaluating the accuracy of the decryption function. Our goal is to maximize the accuracy of the estimated decryption function by transforming the function through each step of the simulation and comparing the accuracy to encourage the walk to travel towards the true function.

3:40–3:55

Further Generalizations of Fibonacci Word Fractals

Darby Bortz and Elias Jaffe
McDaniel College

Generalized Fibonacci words are sequences in a two letter alphabet of ones and zeroes. They are are generated by recursive patterns analogous to various generalizations of Fibonacci numbers. Using a drawing rule, we can represent these words as curves, and use scaling limits to obtain fractals from them. We attempt to translate these constructions into Iterated Function Systems and consider geometric features such as their Hausdorff dimensions.

Lake Michigan **2:00P.M. – 3:55P.M.**

2:00–2:15

Off-Diagonal Ramsey Numbers for Trees with Large Maximum Degree

Josias O. Gomez and William Linderman

King University

The Ramsey number of two graphs G and H, denoted $r(G, H)$, is the smallest integer t such that every 2-coloring of the edges of $K_t t$ in red and blue contains either a red copy of G or a blue copy of H. Ramsey numbers for arbitrary pairs of graphs can be difficult to determine. A well-known conjecture of Burr and Erdős is that $r(T_n) = 2n2$, where T_n denotes a tree with n vertices, and $r(G) = r(G, G)$ denotes a diagonal Ramsey number. A more general conjecture is that $r(T_n, T_m) = n + m2$. Let T'_n denote the unique tree on n vertices with $\delta(T'_n) = n3$ that is a double star, and let T''_n denote the unique tree on n vertices with $\delta(T''_n) = n3$ that is a star with two subdivided edges. We show that for $n \geq 8$, $(T'_n, T''_n) = 2n6$ if n is even, $2n7$ if n is odd.

2:20–2:35

Choose Your Own Adventure: An Analysis of Interactive Gamebooks Using Graph Theory

Daniela Beckelhymer and D'Andre Adams

Southwestern University

"BEWARE and WARNING! This book is different from other books. You and YOU ALONE are in charge of what happens in this story." This is the captivating introduction to every book in this interactive gamebook series, Choose Your Own Adventure (CYOA). Our project uses the mathematical field of graph theory to analyze forty books from the CYOA book series for ages 7-12. Once the digraphs of each book were drawn, we analyzed the digraphs by collecting structural data such as longest path length (i.e. longest story length) and number of vertices with outdegree zero (i.e. number of endings). In this presentation, we will discuss the results of statistical analyses used to compare books by author, year, and reader preference. We will also discuss numerous errors we found in the description of certain books and the publication of others.

2:40–2:55

Two Different Approaches for the Stirling Numbers of the Second Kind

Xueying Chen

Borough Of Manhattan Community College

The Stirling number of the second kind, denoted where and are positive integers, counts numbers of ways to arrange objects into nonempty identical blocks. It is important to count the number of arrangements or patters, but it is impossible to list all of arrangements in practice. Therefore, in this project, we seek the general methods that enable us to count this more effectively. Namely, we will use combinatorics, generating functions and inductive arguments. We get our first formula by counting, with inclusion-exclusion principle: After going over this method briefly, I will give an introductory overview of generating functions and how these can be used to prove formula for the Stirling number of the second kind.

3:00–3:15

Discerning New Patterns in the Generalized Collatz Function Utilizing Big Data Analysis

Shyam Sai

Illinois Mathematics and Science Academy

The Collatz Conjecture has eluded mathematicians for decades. The conjecture that for any initial number n, when recursively inputted to $f(n) = n/2$ if n is even and $f(n) = 3n + 1$ if n is odd will converge to 1 is a point of debate in the field of math for almost 80 years. However, the Generalized Collatz Function is a relatively new function that has not been studied by many. Posited by Zhongfu and Shiming, and in a different form by Bruschi, the form of the Generalized Collatz Function used in this research was $f(n) = n/d$ if $n = 0(\text{mod}\, d)$ and $f(n) = mn + 1$ if n is not equal to $0(\text{mod}\, d)$, where d is a list of consecutive positive primes until the dth prime, the Generalized Collatz is a variable form of the Classic Collatz. We use Mathematica to run the generalized Collatz sequence 1 million times and use big data scanning tools to create visualizations with high-probability to contain a pattern. We discern three new patterns from this big data. One, that all numbers that are divisible by a prime number squared can be set to n, so that, with $m = n - 1$, creates a hailstone sequence ending in $\{4, 2, 1\}$. Two, that all generalized Collatz sequences with $m = n - 1$ will converge to 1, for any divisor, in three iterations. Three, that all Mersenne numbers, when set to m, will, for any divisor and for any initial number, cycle. This project, with the help of 3D graphing technology, was able to find never before seen patterns in a thought-to-be unpredictable function, the Generalized Collatz Function.

3:20–3:35

Magic Squares of Squares of Order 3 over an Integral Domain

Giancarlo Labruna
Montclair State University

A magic square M of order 3 over an integral domain R is a 3-by-3 matrix with entries from R such that elements from each row, column, and main/minor diagonal add to the same sum. If all the entries in M are perfect squares in R, we call M a magic square of squares over R. An open question raised by Martin LaBar is: "Is there an order 3 magic square of squares over the set of integers which has all nine entries distinct?" We approach to answer a related question in a more general way. We claim that over certain integral domains, there exist order 3 magic squares of squares with nine distinct entries. Furthermore, over some integral domains of finite characteristic, magic squares of squares with 2, 3, 5, 7 distinct entries can be constructed. As special cases, there are infinitely many prime numbers p such that there exist magic squares of squares with 9 distinct elements modulo p.

3:40–3:55

Generalized Catalan Numbers

Hannah Pieper and Emily Dautenhahn
Oberlin College and University of Kentucky

There are numerous sets of combinatorial objects that are counted by the Catalan numbers $C(n) = \frac{1}{n+1}\binom{2n}{n}$, and many mathematicians have constructed bijections between these sets. The Catalan numbers can be generalized using parameters p and r, which correspond to the Raney numbers $R_{p,r}(n) = \frac{r}{np+r}\binom{np+r}{n}$, where $R_{2,1}(n) = C(n)$. We present the results of our research on sets counted by generalized Catalan numbers, including combinatorial bijections between the sets to demonstrate that they have the same cardinality. This research was conducted as part of the 2017 REU program at Grand Valley State University.

Lake Huron **2:00P.M. – 3:55P.M.**

2:00–2:15

Optimal Scheduling of Advertisements

Tykeena Watson and Qingxia Li

Fisk University

Advertising agencies want to place television advertisements for their clients which will expose their products to a particular target audience. The project is based on the findings which were developed during the Mathematical Problems in Industry Workshop, held at Duke University June 13-17, 2016. Typically, an advertiser would like a certain amount of impressions for each advertising campaign, either for the target audience or the total audience. Agencies (buyers) place orders with the networks (sellers) for desired commercial slots. The orders come in two types: constrained orders, where the order specifies a certain number of impressions for a particular target audience. In this project, we study several such auction scenarios so that the sellers may maximize their revenue.

2:20–2:35

Demand Side Management Programs in Kentucky

Cara N. Mulligan and Marissa Hartsoe

Centre College

Energy efficiency is a relatively new effort in Kentucky, and an increasing number of programs to promote energy efficiency are being developed and implemented. We examine the efficacy of a specific type of efficiency program, demand side management (DSM) programs. These programs are designed to decrease the amount of energy used during peak times and eventually reduce the overall amount of energy consumed. Through a regression analysis of six major utility companies in Kentucky, we determine the DSM program that is most effective in increasing energy savings for each utility. Additionally, we examine which utility best implements each program.

2:40–2:55

Determining Indoor Position via Wireless Connection

Ricky Hardiyanto

New York City College of Technology

Global Positioning Service (GPS) has been invaluable tool for many types of location-based services and applications. In conjunction with connections to cellular networks and GPS, smartphones can accurately determine your location in the world. But this cannot be used effectively in indoor areas. By relying on wireless connections to set routers throughout the building, we can predict a users location. In a laboratory setting, signal strength will decay linearly as you move farther away from a router, but in reality, it is often blocked by human bodies, thus reducing accuracy. So we take into account the orientation of the device to help compensate these blocking effects. We used a reference set of data in which the signal strength between a hand-held device and routers are measured throughout the test area. With this training data, we modeled the location of a device as a function of the strength of the signal between the device and the routers, using the nearest neighbor method. This work is supported by a MSEIP Grant from the Department of Education.

3:00–3:15

Modeling Ranked Choice Voting in the 2016 Presidential Election

Nicholas Joyner
East Tennessee State University

Ranked choice voting is a system of voting in which voters are allowed to rank the candidates. If no candidate wins 50 percent of the vote, the election automatically goes to another round. The candidate with the least support is eliminated and their votes are redistributed to the voters' next choice. This process of elimination and redistribution continues until a candidate receives over 50 percent of the vote. In this talk, we use predictive models and simulations to analyze several different scenarios if ranked choice voting had been implemented during the 2016 presidential election. This talk will focus on the predictive models used, the implementation of the models, and the numerical results of the simulations.

3:20–3:35

Economics on Networks: Exchange Mechanisms and Strategic Evolution

Devin Chen
University of Richmond

We study the interplay between individuals self-interest and socially optimal outcomes for economic activities on a network in which agents have the opportunity to change network structures. On one hand, agents seek to maximize their individual profits. In addition, agents may achieve mutual benefit either through establishing links or through negotiation, bargaining, and trade. Alternatively, payoffs may also be considered for specific clusters within the network or for the network as a whole, thereby raising the question of how to achieve socially optimal solutions. We conduct research on how strategies evolve as the network changes and how optimal strategies will be adjusted based on whether to maximize individual payoff or maximize socially optimal payoff. This research can help agents weigh between different optimization strategies aligning with their objectives.

3:40–3:55

Network Economics: From Diffusion of Innovations to Marketing Strategies

Hassan Naveed
University of Richmond

The success of a particular marketing strategy can depend on the specific structure of the network in which it is applied. Suppose firms A and B wish to penetrate a particular network which represents a market. If firm A targets an individual, represented by a vertex located within a cluster of high density, while firm B targets a vertex that serves as a bridge between clusters, what is each firm's best response to others marketing strategy? Which firm can expect the greatest payoff from its respective strategy? This payoff can be computed by measurements of speed, efficiency and the number of steps that the two firms take to penetrate the whole network. Using measures of connectivity for graphs and the methods of game theory, we address such fundamental questions. This research can have implications in generating more efficient marketing strategies targeting favorable populations with different network structures.

Conference Room 4M **2:00P.M. – 3:55P.M.**

2:00–2:15

On Minimal Surfaces

Sohair Abdullah

Colorado College

A harmonic mapping is a univalent harmonic function of one complex variable. We obtain a family of harmonic mappings on the unit disk whose images are rotationally symmetric "rosettes" with n vertices, n greater than or equal to 3. For any even number of vertices, the family of harmonic mappings includes an infinite number of minimal surfaces as lifts of the corresponding harmonic mappings. Moreover, for each even number of vertices there is one minimal graph, with piecewise constant height on the disk boundary, that may be completed in real 3-D space by rotations and reflections. In particular, for a four sided rosette mapping we obtain an embedded triply periodic minimal surface.

2:20–2:35

Geometries from Groups

Casey Koch-LaRue

Grand Valley State University

One can measure distances between the compact subsets of a metric space using the Hausdorff metric. A group is a metric space with the word length metric, so we can apply the Hausdorff metric to the collection of subgroups of a finite group. Using the Hausdorff metric, we can define lines containing subgroups and thereby study the subgroup structure of a finite group geometrically. The presenter will showcase the geometries that arise from various finite groups. Relationships will be entertained between the classes to which groups belong, such as dihedral groups and cyclic groups, and the nature of the resulting geometries. This research was conducted as part of the 2017 Student Summer Scholars Program at Grand Valley State University.

2:40–2:55

A Combinatorial Characterization of Curves on the Multiply-Punctured Sphere

Matt Genkin and Joseph Suk

Stony Brook University

The group of components of the homeomorphism group of a surface, the mapping class group, acts on the set of free homotopy classes of curves on the surface (i.e. the set of closed oriented curves on the surface, up to continuous deformation). Recent work has explored the asymptotic behavior of the number of orbits of this action as the self-intersection number k of the curves grows large. We find methods to obtain exact counts of the number of orbits for low k on the punctured torus and the multiply punctured sphere. The punctured torus is a unique case in that this action can be described purely in terms of free group automorphisms. On the multiply punctured sphere, we examine techniques to classify the possible complements of a curve with respect to the surface and study, to what extent, this determines a mapping class group orbit of a curve. This gives an algorithm for counting orbits using planar graphs. We present an outline of this algorithm as well as some asymptotic bounds on the number of orbits implied by our setup. This work was partially supported by NSF DMS-1509280.

3:00–3:15

Generating Mapping Class Groups of Infinite-type Surfaces

Santana Afton and Samuel Freedman
College of William and Mary, University of Michigan

The mapping class group of a surface is an algebraic object that encodes the symmetries of the surface. Dehn showed that the mapping class group can be generated by certain infinite order elements called Dehn twists. It is also known that the mapping class group can be generated only by finite order elements. However, these results do not apply to a “big” surface with an infinite number of holes. Additionally, these big surfaces have new types of symmetries that do not appear in the finite-type case. Patel and Vlamis recently produced the first generating set for an important subgroup of the mapping class group of a big surface, and these are comprised of twists and new types of symmetries called handle shifts. Our work focuses on finding algebraic relations between handle shifts and twists. These relations allows us to optimize the generating set given by Patel and Vlamis. We also construct elements of any finite order in mapping class groups for a large family of infinite-type surfaces. This is joint work with Justin Lanier and Liping Yin.

3:20–3:35

Classification of Unitarizable Low Dimensional Representations of B_5

Paul E. Vienhage
Emory University

The braid group on five strands B_5 is a structure which represents the twisting of five strings into braids, where the group operation which is concatenation of braids. This group is used to study the motion of 5 points in a disk. A representation describes the action of the group on certain complex vector space by identifying it with automorphisms of the vector space via a group morphism. We will present results which classify which of the representations of B_5 are unitarizable, building on previous results which classify the irreducible representations. This topic has direct applications in the mathematics of topological quantum computers, which perform computation by using and braiding anyons. Our results are useful in understanding these types of computers.

3:40–3:55

On Classication of Low-Dimensional Irreducible Representations of B_5

Etude O’Neel-Judy
Northern Arizona University

The design for a topological quantum computer is based on anyon braiding. It uses topology to protect quantum information against decoherence. We may model the space-time trajectory of a system of n anyons with the n-strand braid group B_n. Storing and manipulating information in the representation spaces of B_n is the foundation of Topological Quantum Computation, thus understanding the representations of these braid groups is an important problem. In this talk, we present results on the classication of low-dimensional irreducible representations of B_n, specically of B_5.

Conference Room 4Q **2:00P.M. – 3:55P.M.**

2:00–2:15

Uncovering Percolation Bounds for the $(3, 4, 3, 12)$, $(3, 12^2)$ Lattice

Gabrielle Moss
Johns Hopkins University

A percolation model is an infinite graph, from which edges are deleted independently with probability p. The percolation threshold of an infinite graph is the critical probability p_c above which there exists a connected, infinite component. Much research has focused on calculating exact values and rigorous bounds for the percolation threshold of one-uniform tilings, known as Archimedean lattices. We will investigate how to calculate the percolation threshold of a two-uniform tiling. In a two-uniform tiling, each vertex of the tiling has one of two sequences of faces surrounding it. It is by these vertex configurations that we name the tiling. This talk will be focusing on the $(3, 4, 3, 12)$, $(3, 12^2)$ lattice. Each vertex of this graph has one of two face sequences: triangle-square-triangle-dodecagon, or triangle-dodecagon-dodecagon. We will derive bounds for the site and bond percolation thresholds and discuss the substitution method used for calculating these bounds.

2:20–2:35

Bounds for Bond Percolation Thresholds of 2-uniform Lattices

Jungsoo Park
Johns Hopkins University

A bond percolation model is an infinite graph in which each edge is declared open with probability p independently of the other edges. A percolation threshold of a bond percolation model represents the minimum critical probability of an edge open implies that there exists a positive probability of formation of a connected infinite cluster from the origin. We limit our scope of interest of calculating percolation threshold bounds to 2-uniform lattices. 2-uniform lattices are infinite graphs made of regular polygons with two different vertex configurations. There exist 20 such lattices. We are finding mathematically rigorous bounds for the bond percolations thresholds of some of the 2-uniform lattices using the substitution method. The substitution method is based on stochastic ordering and consists of comparing an unsolved lattice with a solved one. The comparison lattices include but are not limited to Archimedean lattices.

2:40–2:55

Soft Wall: A Model of Casimir Interactions Between a Quantum Field and a Conducting Boundary

Thomas E. Settlemyre
Texas A&M University

The presence of an electrical conductor changes the energy of the surrounding electromagnetic field. As a result, two nearby conductors attract each other in what is called the Casimir effect. In this project we study the case of only one conducting boundary. We further develop the "Soft Wall" model studied by Fulling and others, which was the subject of Whisler and Murray's undergraduate thesis of 2015 at Texas A&M University. In this model, the conductor is approximated by a potential that is a power of the distance into the wall. In the limit of large degree, the potential approaches a perfectly reflecting boundary. The soft wall model aims to solve the "pressure anomaly" problem that comes out of a hard wall model with an ultraviolet cutoff. We report preliminary results from ongoing calculations of the stress-energy-momentum tensor both outside and inside the boundary.

3:00–3:15

Mathematics of Magnetism: the Ising Model for Ferromagnetic Materials

Ariana M. Raya and Nathan Morris
Carthage College

The presence of a magnetic field will cause a ferromagnetic material to polarize, as long as its temperature is cool enough. In this talk, we explain how to model this system mathematically. We follow the Ising model, which uses simple assumptions to represent observed ferromagnetic behavior mathematically, from the particle level up. We show how concepts from probability can be used to determine the overall system magnetization and other properties, including how external conditions have an effect. We will detail our creation of a computer simulation of this model and demonstrate its results.

3:20–3:35

Conditions for Solvability in Chemical Reaction Networks

Mark A. Sweeney

University of Rochester

The quasi-steady-state assumption (QSSA) is a widely used approximation in chemistry and chemical engineering to simplify reaction mechanisms. The key step in the method requires a solution by radicals of several polynomial equations. Pantea et al. showed that there exist mechanisms for which the associated polynomials are not solvable by radicals. We will discuss certain classes of chemical reaction networks (CRN) for which solvability is guaranteed, and provide minimal examples of CRNs for which the QSSA method fails.

3:40–3:55

Calculating Wind Turbine Power Output by Solving Nonlinear Systems of Equations

Paul D. deVries

LaGuardia Community College

A wind turbine generates electricity by converting the kinetic energy of the wind into mechanical energy. The oncoming stream of air can be conceptualized as a cylindrical tube made of annular elements that can be defined by geometrical properties of the wind turbine's blade. How much of the wind's kinetic energy is transferred to the turbine's kinetic energy can be calculated using an iterative method known as the Blade Element Momentum Theory.

Lake Ontario **4:00P.M. – 5:55P.M.**

4:00–4:15

Enumerating Line Arrangements

Connor Halleck-Dube, Elaine Hou, and Daniel Gerhenson
Yale University

Moduli spaces are one of the cornerstones of algebraic geometry. The moduli space of arrangements of lines in the projective plane, constructed by Hacking-Keel-Tevelev and Alexeev, are a higher dimensional generalization of the celebrated moduli space of stable rational curves. Following constructions initiated by Hassett, one can naturally enrich the problem of classifying arrangements of lines in the plane by choosing to weight some of the lines by a number between 0 and 1. We will discuss explicitly, starting for a small number of lines, how the objects parametrized by the moduli spaces change as one varies the weights on the lines. This will then also shed light on how the moduli spaces themselves change, adding another example to the literature on the birational geometry of moduli spaces.

4:20–4:35

Combinatorial Conditions for Vanishing of Local h-Polynomials

Andre Moura, Elijah Gunther, Jason Schuchardt
Yale University

The h-polynomial of a simplicial complex is a polynomial with non-negative integer coefficients, determined by the number of faces of each dimension via inclusion-exclusion (Mobius inversion). In algebraic geometry, it is closely related to the dimensions of homology groups of toric manifolds, and in commutative algebra, it appears as the Hilbert series of the quotient of a Stanley-Reisner ring by a homogeneous system of parameters. We will present new research, using purely combinatorial techniques, on a subtle refinement of h-polynomials, called local h-polynomials of subdivisions. Their name reflects the fact that h-polynomials are expressible as sums of local h-polynomials. We will present research on a problem posed by Richard Stanley a quarter century ago, in the landmark paper "Subdivisions and local h-vectors." Under what combinatorial conditions is the local h-polynomial zero? Under what combinatorial conditions is it nonzero? We will discuss an investigation starting in low dimensions, e.g. for subdivisions of a triangle, and what can be said in general.

4:40–4:55

Straightening Identities in some Twisted Multiloop Algebras

Samuel Chamberlin and David Lindow III
Park University

Twisted multiloop algebras are generalizations of affine Kac-Moody algebras, which have numerous applications in mathematics and physics. For some of these algebras we have formulated and proved various straightening identities, which demonstrate how certain products can be reordered. Such identities can be used to better understand the structure of these algebras and their representations.

5:00–5:15

Straightening Identities in the Onsager Algebra of Sl2

Matthew Samsel
William Jewell College

The purpose of this work is to formulate and prove straightening identities in the Onsager algebra, which is named after the Nobel Prize winning chemist and theoretical physicist, Lars Onsager. We have formulated and proven some of these identities in the Onsager algebra. Our identities allow one to rewrite specific products of basis elements of the Onsager algebra, which are not in the preferred order, as linear combinations of products, which are in the preferred order. Such identities could prove useful to understanding the representation theory of the Onsager algebra. The process of proving these identities involves proving three formulas simultaneously using strong induction.

5:20–5:35

Matrix Factorization

Jacole Elliott, Jocelyn Correa, and Jazmine Morales
Texas Woman's University

Quadratic forms,$f(v) = vAv^T$ where v is a $1 \times n$ vector and A is an $n \times n$ matrix, are one of the most commonly recognized matrix factorizations of polynomial functions in one or more variables. This idea of representing polynomials in quadratic form can be extended with the use of matrix exponentials to rep- resent other scalar functions of one variable as a product of matrices. We will present a matrix factorization for certain scalar functions that can be written in terms of a matrix exponential. This matrix factorization will be in the form $f(x) = Ce^{Ax}B$ where C is a $1 \times (n+1)$ vector, A is an $(n+1) \times (n+1)$ matrix and B is an $(n+1) \times 1$ vector. This triplet of matrices (A, B, C) will be the building blocks for exploring this matrix factorization of certain algebraic combinations of polynomial and trigonometric functions. An interactive calculator that can produce the matrix triplet corresponding to a given polynomial will be demonstrated.

5:40–5:55

On Classification of (Weakly Integral) Modular Categories by Dimension

Kathleen Lee
Whittier College

In this talk, we discuss the classification of modular categories by dimension. The motivation to classify these categories comes from their importance in various fields of mathematics. These fields include topological quantum field theory, conformal field theory, representation theory of quantum groups, vertex operator algebras and applications in physics. Due to the difficulties of classifying these modular categories in general, we will start by looking at modular categories of¡br /¿specific dimensions. In particular we consider modular categories of dimension 2^n and strictly weakly integral modular categories of dimension p^2q^2.

Lake Erie **4:00P.M. – 5:55P.M.**

4:00–4:15

Taffy Pullers: Where Dynamics Meets Geometric Group Theory

Yandi Wu

University of California, Berkeley

The definition, study, and construction of symmetries is a unifying theme in mathematics. Geometric group theory explores aspects of groups theory, such as symmetry, using geometry and topology. For instance, one can define surface symmetries using classes of homeomorphisms: continuous deformations of a surface. One way to understand symmetries is to observe how iterations of a homeomorphism perturb the surface over time. For example, we can visualize the cross section of a taffy puller, where the taffy is a simple closed curve in a thrice-punctured plane and the pulling action a homeomorphism. We can then calculate the efficiency of the taffy puller to measure how much the plane is stretched. In this talk, I provide background on geometric group theory and introduce my work in exploring how certain homeomorphisms "mix" the surface around. This is joint work with Bal'azs Strenner, Ian Katz, and Yihan Zhou under the supervision of Dan Margalit.

4:20–4:35

Glider World: A Cellular Automata with Complex Rules but Simple Behavior

Nathan Dwyer

Cornell College

In this talk we discuss Glider World, a new cellular automata that uses complex rules to ensure simple behavior. Other cellular automata, such as Conways Game of Life and Rule 110, are known for complex behavior arising from simple rules. For example, Conways Game of Life has a very simple rule system, yet has incredibly complex behavior, such as the collision of gliders, which are patterns that periodically translate across a grid. Glider World changes this. Instead of simple rules resulting in complex behavior, complex rules result in simple behavior. It is designed to model some patterns common to many other cellular automata, such as Conways Game of Life, by abstracting away these patterns (namely gliders, eaters, and fanouts) into single cells. Behavior of states is sharply limited, with all gliders consisting only of a single cell, and all glider collisions resulting in an empty cell. Finally, we show that Glider World is Turing complete by constucting a simulation of Rule 110 in Glider World.

4:40–4:55

Analysis of the Hyperbolic Points of the Modulated Logistic Map

Khoa Tran

University of Illinois at Urbana Champaign

As suggested by Elhadj and Sprott [1] in Section 3, we are studying the hyperbolic nature of their modulated logistic map. First, we find the fixed points of the map and determine the nature of these points as attractive, repelling, or saddle points by the three selected parameters a, b, and c. We determine the behavior of these points by carefully considering the appropriate domain in 2-dimension and our familiarity of the original logistic map, which is only dependent on one of the variables. We hope to further determine the details of the different behaviors including the stable and unstable manifolds of the saddle points. Zeraoulia Elhadj and J.C. Sprott. Some open problems in chaos theory and dynamics. Int. J. Open Problems Compt. Math, 4(2), 2011.

5:00–5:15

Numerical Experiments on R-K Methods for Lie-Invariant ODEs

Jonathan Gonzalez Davila
Lehman College, CUNY

We present our experiments pertaining to Runge-Kutta methods for ordinary differential equations observing invariance on a lie group. These methods have the advantage that computed solutions are restricted to a submanifold of the domain via an exponential map. Applications can be found in physics, engineering, and numerical linear algebra. We demonstrate our results against classical methods.

5:20–5:35

No Talk

5:40–5:55

No Talk

Lake Michigan **4:00P.M. – 5:55P.M.**

4:00–4:15

Generalizing the Tower of Hanoi

Alexander Grover

St. Norbert College

The smallest number of moves to solve the 3-peg Tower of Hanoi is well-known, but when more pegs are available, the problem becomes quite difficult. We observe several patterns for arbitrary numbers of disks and pegs, and present proofs of some of those patterns.

4:20–4:35

On the Properties of k-th-Order Fibonacci-like Polynomials

Katherine T. Arneson, Jason W. Bruce, and Alexandra I. Embry

St. Olaf College, University of Rochester, Indiana University

For a fixed positive integer $k \geq 1$, we introduce recursively defined polynomial sequences given by $G_n^{(k)}(x) = xG_{n-1}^{(k)}(x) + G_{n-k}^{(k)}(x)$ and $H_n^{(k)}(x) = xH_{n-1}^{(k)}(x) - H_{n-k}^{(k)}(x)$ with initial conditions $G_0^{(k)} = G_1^{(k)} = ... = G_{k-1}^{(k)} = 1$ and $H_0^{(k)} = H_1^{(k)} = ... = H_{k-1}^{(k)} = 1$. Note that for $k = 2$, $G_n^{(2)}(x) = F_{n-1}(x) + F_{n-2}(x)$ where $F_n(x)$ are the Fibonacci polynomials, with $F_0 = 1$ and $F_1 = x$. Further, when $x = 1$, $G_n(1) = F_n(1)$. In this talk we present some interesting properties of $G_n^{(k)}$ and $H_n^{(k)}$, as well as some other similarly defined polynomial sequences, and we will primarily focus on studying their combinatorial applications along with their analytic nature. In particular, we will establish, for all $k \geq 3$, a uniform asymptotic result for the maximal real roots of $H_n^{(k)}$, provide similar results for the minimal real roots of $G_n^{(k)}$, and explore interesting integer sequences that arise from the polynomials.

4:40–4:55

On a Solution to the Oversize Pancake Flipper Problem

Gennifer Elise Farrell and Parker Servello

Slippery Rock University

Google Code Jam 2017 featured a challenge titled ‘The Oversize Pancake Flipper’. In this problem a chef is cooking pancakes arranged on the griddle in a single line. These pancakes have two sides, happy side up and sad side up. The chef does not have a spatula that is capable of flipping one pancake at a time. He only has a spatula that can flip a fixed number of two or more pancakes at a time. His spatula is also not bigger than the total number of pancakes that need to be flipped. The challenge is twofold. Firstly, one must determine –given any number and initial orientation of individual pancakes, and given any valid spatula size– whether it is possible that the pancakes can be flipped so that they are all oriented happy side up. Secondly, given that it is possible to flip all the pancakes to that they are oriented happy side up, the minimum number of flips necessary to accomplish such a feat must be found. This presentation outlines and explores an algorithm that has been proven to satisfy the two parts of ‘The Oversize Pancake Flipper’ challenge.

5:00–5:15

Border Value Theorem: Peeps Into The Goldbach Conjecture

Rajatava Mukhopadhyay
Patha Bhavan and JBNSTS

A seemingly easy problem including prime numbers which has ridiculed mathematicians all over the world for over 275 years has been daringly attempted by me with a dream of solving it. Although I don't claim to have chalked out a complete rigorous proof for the conjecture, I believe to proceeded to some extent in this regard, which will, I guess, assist further research schemes in this field in future.

5:20–5:35

No Talk

5:40–5:55

No Talk

Lake Huron **4:00P.M. – 5:55P.M.**

4:00–4:15

A Machine Learning Approach to Aircraft Sensor Error Detection and Correction

Renee Swischuk and Douglas Allaire
Texas A&M University

The pitot static system provides critical airspeed information and consists of two ports located outside of the aircraft making them vulnerable to interference and failures. If an aircraft has access to redundant sensor output, then it can be trained to autonomously recognize errors in faulty sensors and learn to correct them. In this work, we develop a novel machine learning approach to detecting aircraft sensor failures and predicting corrected flight data using an offline/online paradigm. We demonstrate our methodology on flight data from a four engine commercial jet that contains failures in the pitot static system to show the safety benefits of our system in flight. Autocorrelation of incoming pressure data is used to classify the state of the pitot static system and feature selection is performed on high dimensional sensor output to create an offline library. This library is used to train a regression model to make real time corrections to airspeed data. Future work is discussed in the areas of weighted metrics for classification and dimensionality reduction techniques.

4:20–4:35

Optimizing Ambulance Distribution in Wayne County, West Virginia

Kevin C. McDaniel
Marshall University

A proposal to upgrade the ambulance services in Wayne County, West Virginia is being designed, and the math department at Marshall University was contacted with a request for assistance in analyzing the available data and informing the designer of potential improvements to the proposal. A major challenge in designing the new ambulance service was determining how to distribute ambulances throughout the county, as there is no simple way to compare the performance of one distribution to another. In this presentation, we will discuss how we overcame this challenge to find well-optimized ambulance distributions. We wrote a simulation that uses historical call data to model how ambulances responded to emergency calls as they occurred in 2016, and used this simulation to estimate the performance of different distributions. Extending this approach, we additionally performed a multi-objective optimization of the distribution of ambulances throughout the county, minimizing the estimated cost and average response time. This optimization was made possible through the use of Big Green, a high performance computing cluster at Marshall University.

4:40–4:55

Empirical Runtime Testing for the Envy-free n-person Cake Cutting Algorithm

Kenan C. Bitikofer

Goshen College

"Cake cutting" is a term used by mathematicians and computer scientists to describe the problem of finding equitable ways to divide a resource between agents who may value different portions of the resource differently. One of the more difficult requirements for such a division is that no person would prefer to have another's slice rather than their own (envy-free). It was until recently an open problem whether there existed a bounded algorithm for dividing such a resource in an envy-free manner between N agents. In 2016, Hariz Aziz and Simon Mackenzie published a solution to this problem, with just such a bounded algorithm for n people. The algorithm they propose has an upper bound of $n^{n^{n^{n^{n^{n}}}}}$, but the computations actually required by the protocol are likely far fewer. In our research we seek to find benchmark measures of the performance of this algorithm, and seek to computationally determine if the upper bound can be significantly reduced. We will also compare typical runtimes with the runtimes of other cake cutting algorithms which are unbounded or only partially allocate the resource.

5:00–5:15

A Lower Upper Bound on Discrete and Envy-Free Cake Cutting

Christian L. Bechler

Goshen College

We examine the problem of finding an envy-free division of cake between n people through a discrete algorithm which returns a result in a bounded number of steps. A cake is understood as an interval from $[0, 1]$ for which each player has valuation functions over every disjoint subinterval and an envy-free division simply means that no person would prefer the piece held by another person over their own. In 2016, Aziz and Mackenzie proposed an algorithm which satisfied these criteria. However, the upper bound was unnecessarily large: $n^{n^{n^{n^{n^{n}}}}}$ and the authors suggested a lower upper bound was plausible. This paper provides an algorithm which works with an upper lower bound by altering and simplifying the Core, SubCore and GoLeft Protocols in Aziz and Mackenzie's paper.

5:20–5:35

Traffic Flows with Self Driving Cars: A Spacial Approach

Tim Holdsworth, Nick Wahl, and Erick Perez
University of San Diego

We modeled the likelihood of traffic developing at a given time based on the number of cars on the road and how what percentage of the cars are self driving. We focused specifically on the spatial density of cars on the road. To do this, we built on previous models for safe braking distance as a function of speed, and we also factored in average car length. Self-driving cars are able to drive closer to cars in front of them because they have quicker reaction times than humans, but the distance is still a function of velocity, as the human body has limits on what a comfortable deceleration looks like. In the case where a self-driving car is behind another and they are communicating, the space savings can be amplified as the cars can essentially brake and accelerate in sync. We incorporated traffic fluctuations during a normal day as well, overall developing a better idea of the conditions under which self driving cars can create the greatest social benefit.

5:40–5:55

Modeling Futuristic Traffic Flow

Julia Buczek, Jacob Rubinstein, and Alycia Holmes
Roosevelt University

In doing the Mathematical Competition in Modeling for 2017, we chose to model the effects on traffic flow when self-driving cars are introduced to highways. Our model introduced the conceptual ideas behind the behavior of self-driving cars, and used mathematics to support our hypothesis. We are heading towards a technology filled future and autonomous cars are going to be the norm, so we wanted to create a model in order to begin understanding the relationship between self-driving and manually driven vehicles.

Conference Room 4M **4:00P.M. – 5:55P.M.**

4:00–4:15

Multi-Crossing Links and Hyperbolic Volume

Luya Wang and Daishiro Nishida
Princeton University and Williams College

We present multi-crossing projections of knots and links and an improved upper bound on hyperbolic volumes using these projections.

4:20–4:35

Tiling, Volume and Alternating Links

Braeden Reinoso and Zhiqi Li
Haverford College and Williams College

Given a tiling by polygons of the sphere, Euclidean plane, or hyperbolic plane, we describe how to turn it into an alternating link on the torus and how this can help us classify tilings.

4:40–4:55

Alternating Links with Multi-Crossings

Carlos R. Albors-Riera, Beatrix Haddock, Colin Adams,
Zhiqi Li, Daishiro Nishida, Luya Wang, and Braeden Reinoso
Harvard University, Williams College, Princeton University, Haverford College

We extend the concept of alternating to multi-crossing projections of links and associate to these links hyperbolic volumes.

5:00–5:15

Homotopy Commutative Algebras, Knots and Graphs

Maksym Zubkov
University of California, Irvine

The simplest form of knot theory involves the study of regular knot which is defined as a closed loop in three-dimensional Euclidean space $\mathbb{R}^3$. One of the main problem of knot theory is detecting whether the two given knots are the same or not. Mathematicians developed certain invariants (Alexander and Jones polynomials, Vassiliev invariants, and etc.) that partially solved that problem. One of the standard techniques is to construct for each knot a graph and study invariants on this graph. During my talk, we are going to talk about commutative and non-commutative versions of graph complex and the difference between them. Also, we will discuss the methods which are based on combinatorics of Eilenberg-Zilber contraction, "surjection operations" of McClure and Smith, and homological perturbation lemma. That graph homology complex will help us to compute the homology of the "graph configuration space" for a topological space X (i.e. an n-fold cartisian product X_n with some of its diagonals removed). This is expected to give a concrete combinatorial model for knot invariants recently defined via the abstract technique of factorization homology.

5:20–5:35

DNA Origami and Unknotted A-trails in Torus Graphs

Ada Morse, William Adkisson, Jessica Greene, David Perry, and Brenna Smith
University of Vermont, University of Chicago, Saint Michael's College

Motivated by the problem of determining unknotted routes for the scaffolding strand in DNA origami self-assembly, we examine existence and knottedness of A-trails in graphs embedded on the torus. We show that any A-trail in a checkerboard-colorable torus graph is unknotted and characterize the existence of A-trails in checkerboard-colorable torus graphs in terms of pairs of quasitrees in associated embeddings. Surface meshes are frequent targets for DNA nanostructure self-assembly, and so we study both triangular and rectangular torus grids. We show that, aside from one exceptional family, a triangular torus grid contains an A-trail if and only if it has an odd number of vertices, and that such an A-trail is necessarily unknotted. On the other hand, while every rectangular torus grid contains an unknotted A-trail, we also show that any torus knot can be realized as an A-trail in some rectangular grid. Lastly, we use a gluing operation to construct infinite families of triangular and rectangular grids containing unknotted A-trails on surfaces of arbitrary genus. We also give infinite families of triangular grids containing no unknotted A-trail on surfaces of arbitrary nonzero genus.

5:40–5:55

The Mathematics of Contra Dance

Nicholas A. Rockstroh and Jennifer Miller
Bellarmine University

Contra dance is a form of American community couples dancing in which dancing couples are arranged in two long lines. Each dances figures are most commonly performed in two couple subsets of those lines. Said figures are grouped into 8 count sequences, with each dance typically comprised of 8 of these sequences. By the end of the complete 64 count sequence, each couple has "progressed" at least one place to meet a new couple to dance with. My work explores the ways mathematical ideas such as group theory and knot theory can be used to describe Contra dances. For example, consider the set of 8 count sequences of figures that preserve the relative positions of the dancers in the group of 2 couples. This set can form a group that is isomorphic to the dihedral group of the square. Additionally, the basics of knot theory can be used to describe the motions of the couples throughout the entire set as they progress up and down the line. Taken together, these ideas form the basis of a method for describing, with surprising precision, the motions of the dancers in a Contra line. This method further enables a technique for examining various dances to determine their similarities and differences, which has the potential to be very useful for Contra callers who seek to create interesting and diverse programs.

Conference Room 4Q **4:00P.M. – 5:55P.M.**

4:00–4:15

Proving the Proof-less Profitable

Meredith C. Sheeks
Lee University

From the time of the Pythagoreans, who sought mathematics for the sake of furthering knowledge itself, to the organization of mathematical proof by Euclid in his Elements, and finally to the competitive mindset of Hilbert's challenge of twenty-three problems to be solved during the 20th century, the shift from pure exploration to rigorous proof in mathematics can result in often disappointment when problems are not as easily solved as first anticipated. This poster presentation does a survey of the mathematics involved regarding problems in mathematics that have given mathematicians an unexpected challenge but have resulted in, through the prolonged process, additional mathematical progress that would not have been obtained otherwise. When Hippocrates set out to solve the quadrature of the circle, he did not find one solution to the quadrature of the circle, but he instead found the quadrature of many other curved regions and polygons. Fermat left behind several theorems un-proven, but as a result of the struggle of mathematicians for centuries to solve Fermat's Last Theorem, many additional conjectures were formulated to be true along the way if and only if mathematicians could prove Fermat's Last Theorem to hold. When finally proven in 1995, all of the additional conjectures that were formulated along the way in the attempt to prove Fermat's Last Theorem were also proven to be true. Lastly, the correspondence of G.H. Hardy and Ramanujan and their attempt to solve the Riemann Hypothesis resulted instead in more progress on Goldbach's Conjecture. The work of Hippocrates, Fermat and Ramanujan and Hardy reveal that throughout the history of mathematics more can be gained along the process of mathematics than what first end-goal may meet the eye.

4:20–4:35

The History of the Definite Integral

Helen Cooney
Neumann University

This paper discusses the history of the definite integral. It begins with the motivation for the definite integral. In particular, we look at the ways in which ancient societies calculated and estimated areas both of common shapes and of areas under curves. Next, we examine the derivation of the definite integral. In particular, we look at the works of Caucy, Darboux, Dirichlet, Stieltjes, Riemann and Lebesgue. The various formulations of the definite integral are compared and contrasted. Following this, we discuss modern advances in the calculation of definite integrals, in particular, calculation using computer software. Finally, we discuss potential future applications of the definite integral.

4:40–4:55

A Historical Survey of French Number Theory

Christopher G. Henson
Texas A&M University

The objective of this paper is both to provide historical context for the development of number theory, and to examine content that might be unavailable to the some readers because of linguistic limitations. It is particularly illuminating to see how the field developed in its infancy, and the ingenious methods employed in the search for intermediate results of what would become with time iconic theorems. This paper will examine two lines of development concerning the work leading up to the Prime Number Theorem and Fermat's Last Theorem as made by Adrien Legendre, P. L. Chebychev, and Augustin Cauchy. Particularly in the case of the latter, the work we will examine is far removed from the machinery that would eventually be required for a proof of such a theorem, but is interesting in light of the insight to how a masterful mathematician approached a new subject.

5:00–5:15

My Mathematical Mice - Modeling Neuroblastoma Tumor Growth in Mice using a System of Ordinary Differential Equations

Yixuan He, Anita Kodali, and Dorothy Wallace
Dartmouth College

Neuroblastoma is the leading cause of cancer death in young children. Although treatment for neuroblastoma has improved, the five year survival rate of patients with high risk neuroblastoma still remains less than 40 percent. Recent studies have indicated that bevacizumab, an anti-VEGF drug used in treatment of several other cancer types, may be effective for treating neuroblastoma as well. However, its effect on neuroblastoma has not been well characterized. While traditional experiments are costly and time consuming, mathematical models are capable of simulating complex systems quickly and inexpensively. Mathematics can provide huge contributions to experimental cancer investigation as it is a powerful tool to test hypotheses and confirm experiments, allowing researchers to gain a better understanding of cancer growth dynamics and to design better treatment strategies. In this study, we present a simple mathematical model of vasculature tumor growth of neuroblastoma IMR-32 that is complex enough to replicate experimental data on a range of tumor properties in vivo and provide quantitative insight into tumor vasculature, while restraining the number of parameters in the system of differential equations to the number of measured quantities. We then implemented various treatment regimes of bevacizumab, the leading anti-VEGF anti-cancer drug, to study its effect on neuroblastoma growth dynamics. Our results improve current understanding of neuroblastoma development in vivo as well as bevacizumab pharmacodynamics in order to facilitate the design of optimal treatment strategies.

5:20–5:35

No Talk

5:40–5:55

No Talk

Conference Room 4C **9:10A.M. – 10:25A.M.**

9:10–9:25

Fractals And Iterated Function Systems

Marko Saric
Benedictine University

Fractals are self-similar structures which can be defined by an iterative process. In this paper, we use a computer program and iterated function systems (IFSs) to study the role of matrix norms and its effect on the type of fractal generated. In particular, we propose a connection between the spectral norm of the matrices in the IFS and the type of attractor that is graphed.

9:30–9:45

Cross-Sections for One-Parameter Matrix Groups

Sophia Maniscalco
Bridgewater State University

Let G be a matrix group acting linearly on an n-dimensional real vector space. The existence of a computable cross-section for the orbits produced by the action of G plays a central role in wavelet theory and representation theory of matrix groups. Structural conditions on G allowing the existence of a cross-section have been described in various settings. In this talk, we will consider the following specific case. Let G be a one-parameter matrix group acting linearly on an n-dimensional real vector space. Assuming further that the eigenvalues of the matrix generating G are all real, we shall show how to compute explicit cross-sections for the corresponding orbits.

9:50–10:05

Gabriel's Horn, Centers of Mass, and Higher Dimensions

Sarah Chamberlain
SUNY Fredonia

Gabriel's Horn is one of the most fascinating concepts that arise in Calculus. Imagine the concept of a horn infinitely long, which contains finite amount of paint, but cannot be painted. Conceived by Evangelista Torricelli in 1644, its counterintuitive appeal was immediate and lasts even in modern calculus books. What about its center of mass? We will examine this issue as well as extending these results to ordinary horns, other "horn-like" objects, and 4 dimensional horns.

10:10–10:25

Morita Equivalence for Groupoids of Directed Graphs

Vincent Houser Villalobos
University of Texas at Tyler

Given a directed graph E, it is possible to construct a topological groupoid from the infinite paths in the graph, which allows one to bring powerful groupoid techniques to bear on the graph. We will discuss how certain graph moves (such as sink removal, in-split, out-split, and the Cuntz splice) affect the structure of the groupoid. In particular, we will investigate whether graphs obtained from E by applying such moves have groupoids that are Morita equivalent to that of E. Our study is motivated by previous results showing that certain graph moves produce Morita equivalent graph C^*-algebras.

Conference Room 4D **9:10A.M. – 10:25A.M.**

9:10–9:25

Mathematics Underlying Rotational Kinematics

Eric Louis Montag

Randolph-Macon College

The problem of parameterizing the group of rotations in Euclidean 3-space has been of interest since 1776 when Euler first proved his famous rotation theorem. Euler's notion was extended by the work of Rodrigues (circa 1841), Hamilton (circa 1843), and Cayley (circa 1845). Rodrigues derived a formula that permits direct calculation under certain conditions, while Hamilton generalized the underlying mathematics by introducing the new algebra of Quaternions that enabled the parameterization of the rotation group. Meanwhile Cayley developed Cayley Transformations, a mapping between real skew-symmetric matrices and special orthogonal matrices. This presentation focuses on methodologies for calculating orthogonal coordinate transformation matrices $A(t)$ between two frames of reference F_a and F_b, where F_b is attached to a rotating body and rotates with angular velocity $\omega(t)$ relative to F_a, which we may regard as fixed in space. These methods for calculating $A(t)$ are discussed in light of a physics-imposed kinematical constraint. Parameterizations of $A(t)$ are presented and discussed in the context of published research findings, indicating that no three-parameter system can produce a continuous, global and non-singular transformation, but that a four-parameter representation suffices.

9:30–9:45

Application of Fractional Calculus in Modeling Cell Viscoelasticity

Anh Thuong Vo

Creighton University

Fractional calculus is a tool which involves taking derivatives or integrals to non-integer orders. In recent decades, fractional order differentiation and integration have been used to study differential equations with real world applications ranging from the natural sciences and engineering to social sciences and economic models. Here we used advanced theoretical and computational methods to model the viscoelastic properties of cells. Using Mathematica and Matlab, we compared numerical solutions to classical and Mittag-Leffler fractional calculus models of various PDE's governing viscoelastic cells. Our results show that fractional models fit the data better than the integer models. Specifically, the fractional order models of viscoelasticity that we have used appear to render dynamic properties of cells more tractable, enabling better biophysical characterization of cells in health and disease.

9:50–10:05

Mathematical Analysis of Heat Capacity and Thermodynamic Relations in a Magnetic Field

Jeremiah Bouza
Kent State University

Recently, researchers have looked into thermodynamic relations under magnetic fields and have found unexpected results. In this project, we analyze experimental data of heat capacity versus temperature in various strengths of magnetic fields. The data used is from experiments done at constant pressure, so the focus will be on the corresponding specific heat capacity value C_P Using Maxwell Relations, certain relations of thermodynamic values to heat capacity could previously be predicted, including compressibility, thermal expansion, and temperature. In the presence of a magnetic field, materials have been found to act in ways that contradict the predicted heat capacity to temperature relations. Our goal is to analyze this relation and how other thermodynamic coefficients behave under various magnetic fields.

10:10–10:25

Approximating Nonlinear Differential Equations using the Adomian Decomposition Method

Donald Wayne Fincher
Kent State University

In this work, we show how to use the Adomian decomposition method (ADM), pioneered by George Adomian, to find analytical approximate solutions of nonlinear differential equations. ADM is an important tool for mathematicians and engineers because it does not discretize the domain or employ perturbation techniques, nor does it linearize the equation. Therefore, the essential physical character of the mathematical model is preserved in the corresponding analytical approximation. Finally, we demonstrate the method by applying it to the Duffing oscillator, which is a second order nonlinear differential equation that models forced vibrations of industrial machinery, is immune to white noise making it useful for weak signal detection, and has found to be applicable in the study of flexural nanomechanical resonators which allow for highly accurate measurements.

Conference Room 4C **2:00P.M. – 3:55P.M.**

2:00–2:15

Pattern Avoidance in a Generalization of Stirling Permutations

Bryan Pennington
University of Texas at Tyler

Given a permutation, π, we say π avoids a pattern, σ, if there does not exist a sequence in π with the same relative order as σ. We studied pattern avoidance on a generalization of Stirling permutations obtained from rooted, ordered trees. This work was completed as part of the REU at University of Texas in Tyler.

2:20–2:35

A New Triangle Generation of Generalized Genocchi Numbers Using Rook Placements on Genocchi Boards

Vasily I. Zadorozhnyy
Grand Valley State University

The two-dimensional rook theory can be generalized to three and higher dimensions by assuming that rooks attack along hyperplanes. Using this generalization, Alayont and Krzywonos defined two families of boards in any dimension generalizing the triangular boards of two dimensions whose rook numbers correspond to Stirling numbers of the second kind. One of these families of boards is the family of Genocchi boards whose rook numbers are the Genocchi numbers. This combinatorial interpretation of the Genocchi numbers provides a new triangle generation of the Genocchi numbers. In our project, we investigate whether such a similar triangle generation exists for the generalized Genocchi numbers in four and five dimensions.

2:40–2:55

Network Community Detection based on Measures of Centrality

Zachary J. Ash
Grand Valley State University

When analyzing networks, it can be very informative to examine the centrality (the importance to the graph's connectivity) of various vertices and edges, as well as to detect any communities (groups of densely-connected vertices). These characteristics can provide a very important description of how the network functions. We explore and compare the effectiveness of some of the typical measures of vertex and edge centrality, as well as some of the commonly implemented algorithms for community detection. We also introduce some new measures of edge centrality based on various measures for vertex centrality. These edge centrality measures are then used as the basis for presenting several modified versions of the Girvan-Newman community detection algorithm. Relative strengths and weaknesses of these centrality measures and community detection algorithms are discussed.

3:00–3:15

Operations Generating Palindromic Triangular Arrays

Katherine A. Mantych

Elmhurst College

One of the best known palindromic triangular arrays is Pascal's Triangle, where each row consists of the binomial coefficients and is generated by the row preceding it. Another palindromic triangular array can be formed with the Eulerian numbers, which represent the coefficients of the Eulerian polynomials coming from the closed form of the nearly-geometric series $\sum_{n=0}^{\infty} \frac{n^k}{x^n}$. We examine the results of using seed triangular arrays, like Pascals and the Eulerian Triangles, to generate new triangular arrays through an iterative process. We also explore further operations that maintain the symmetric structure of palindromic triangular arrays.

3:20–3:35

Rho, Rho, Rho Your Boat: On the Minimum Size of an h-fold Restricted Sumset of an m-element Subset of $\mathbb{Z}_p^r$

Jason Bailey Heath

Gettysburg College

We are interested in finding the minimum size of an h-fold restricted sumset of an m-element subset of $\mathbb{Z}_p^r$ for some prime number p, given by the notation $\rho\hat{}\left(\mathbb{Z}_p^r, m, h\right)$. Here, we find upper bounds for $\rho\hat{}\left(\mathbb{Z}_p^r, m, h\right)$ for all h, m, p, and r for which $h > p$.

3:40–3:55

From Simplest Recursion to the Recursion of Generalizations of Cross Polytope Numbers

Yutong Yang

Kennesaw State University

”This project involves investigations in the mathematical field of Combinatorics. The investigations extend and vary results of Professors Steven Edwards and William Griffiths, who recently found a new formula for the cross-polytope numbers. My research is focused on $E_k(n, m)$ and $O_k(n, m)$, which are two distinct combinatorial expressions that are in fact equal and generalizations of the cross-polytope numbers. We proved that E_k and O_k share the same recurrence formula of E and O algebraically by using Pascals identity. Also we found that there exists a reflection in the table and we proved it by algebra. We find that E_k is divisible by $2^(k-1)$. Each column of E_k and O_k satisfies a recursive formula. ”

Conference Room 4D **2:00P.M. – 3:55P.M.**

2:00–2:15

Vanishing Dissipation Limits For a Generalized Magneto-hydrodynamic Equation

Danielle D. Pham

Creighton University

The Magnetohydrodynamic (MHD) system of equations governs kinematic fluids that are subjected to a magnetic field. The equation is a combination of the Navier-Stokes equation and Maxwell's equations. Due to the difficulty in solving the MHD system, it has become common to study approximating versions of the equation, including the MHD-α system, which regularizes the velocity field in exchange for the addition of non-linear terms. Both the kinematic and magnetic parts of the MHD-α system have diffusive terms which dissipate the initial energy of the system. Setting those terms equal to zero returns the Ideal MHD-α system.

The goal of this project is to show that solutions to the MHD-α system with diffusion will converge to the Ideal MHD-α system as the diffusion parameters are sent to zero by adapting known results for the analogous problem of determining when solutions to the Navier-Stokes equation will converge to a solution of the Euler Equation.

2:20–2:35

Mathematical Modeling, Methods, Analysis, and Applications: Artificial Intelligence

Claire Bodemann

Eckerd College

We propose to develop a mathematical model of dynamic processes in artificial intelligence. In addition, we will exhibit the validity of the mathematical model and develop mathematical tools to analyze some features of artificial intelligence. Role and scope of the presenter's results will be illustrated. This research is supported by the US Army Research Office, US Army Grant No: W911NF-15-1-0182.

2:40–2:55

Predicting U.S. Childhood Obesity through Mathematical Modeling

Britney Mazzetta

Ithaca College

In the past 50 years, observational studies have shown obesity to be the most prevalent nutritional based disease in the most affluent countries of the world, including the United States. A variety of diseases, which results in a higher mortality rate, have been linked to those who suffer with obesity. This link raises concerns and has led to an increase in preventative efforts to reduce this rate through several public health programs in and out of schools to, hopefully, reverse the epidemic trend. We will provide a unique interpretation to how the trend can be modeled by focusing on the social and nonsocial factors that influence obesity and the degree at which those factors influence people by applying United States' data to a new mathematical model. This model will adopt similar strategies that were developed by Lucas Jodar and his colleagues (2008). Interpretations of population changes in regards to obesity trends can then be made. Through these models, predictions can also be formed that will identify future childhood obesity trends in the US. This rate can then be used in a predictive way as a way to form implications on how the problem can be reduced and hopefully resolved.

3:00–3:15

Constructing the Airy's Function, and Other Solutions within a Special Class of ODEs

Brittany Sheahan
St. Norbert College

We examine a class of homogenous, second order, linear ordinary differential equations that take the form $y'' + f(x)y = 0$ where the coefficient on the y term is the power function $f(x) = y^n$. The case where $n = 0$ provides the familiar constant coefficient solution. The case where $n = 1$ provides a solution called the Airys function that has been named after the founder, George Biddell Airy (1801-1892). In this talk, we offer some brief historical remarks about George Airy. We derive the Airys function by imposing a power series solution in the corresponding $f(x) = x$ differential equation. We further this work by organizing solutions of the ODE for all integers $n > 1$. Interesting and predictable patterns emerge. We introduce some challenges for constructing solutions of the ODE for integers $n < 0$.

3:20–3:35

An Exploration in Electrical Circuits and Mass-Spring Systems

Hanna Strohm
St. Norbert College

In this talk, we derive the mathematical models for both the displacement on a mass induced by a forced, damped spring motion and for the charge in an RLC electrical circuit. Both models are linear, nonhomogeneous, second-order, ordinary differential equations. We compare and contrast selected solutions with a focus on applications. We introduce the conditions under which this differential equation relates to the motion of a pendulum.S

3:40–3:55

Legendre's Equation

Colleen Mandell
St. Norbert College

In this talk, we solve Legendre's equation, which is a linear, homogeneous second-order, ordinary differential equation. We construct the Legendre polynomials through a power series solution approach. The Sturm-Liouville theory is introduced to demonstrate how Legendre polynomials are used to solve the Laplace equation in spherical coordinates.

Conference Room 4K **3:00P.M. – 3:55P.M.**

3:00–3:15

Trajectories on Homothety Surfaces

Slade Sanderson
Pepperdine University

A homothety surface is constructed by gluing the sides of polygons in the plane by homotheties—compositions of scalings and translations. Homothety surfaces generalize translation surfaces, which have been well-studied for several decades. We examine long-term behaviors of linear trajectories on homothety surfaces, with an emphasis on genus-2 surfaces.

3:20–3:35

A Hypersurface Based Approach for Determining Topological Relations between Objects of Co-dimension 1

Jordan Vincent Barrett
Syracuse University

Most of the work that has been done concerning the determination of topological relations is based on the premise that the objects are of codimension 0 . Though there have been multiple efforts to determine relations of codimension 1 between objects of different dimension, there is a need for a general approach. This study sought to produce a general method for determining topological relations of codimension 1 using formalisms related to hypersurfaces. This was achieved by using a construct similar to the 9-intersection matrix to determine all of the possible orientations of hypersurface in $\mathbb{R}^n$. After the set of possible configurations of two hypersurfaces was determined, the matrices corresponding to these configurations were organized into an extended version of the 9-intersection matrix, that treated the hypersurfaces as $n-1$ dimensional pseudo-exteriors for $(n-1)$ dimensional objects in n. Later, theorems were written and employed as a tiered negative constraint sieve that was used to determine a set of viable matrices. Two sets of matrices were determined, with cardinality on the order of 5,431 and 513, respective to the two sets. While these are supersets containing the relations currently considered by the literature, the set must be further constrained to effectively interface this method with current theory. Alternatively, it may be demonstrated in the future that the seemingly extraneous relations are applicable in higher dimensional space.

3:40–3:55

Splitting Numbers of Ten Crossing Links

Rebecca Caryl Sorsen
University of Nebraska-Lincoln

The splitting number of a link, L, is the minimum number of between-component crossing changes required to produce a completely split link. All splitting numbers of links with nine or fewer crossing were known prior to this research, so we were interested in links with 10 crossings. We explored five different methods, each increasingly more difficult than the last, to uncover the splitting numbers of all 287 10-crossing links.

Conference Room 4C **4:00P.M. – 6:15P.M.**

4:00–4:15

Algorithms and Patterns for Computing Arithmetical Structures of Graphs

Joshua R. Wagner
Gettysburg College

Arithmetical structures are created by labeling the vertices of a graph so that each vertex is a divisor of the sum of its neighbors. The question is, given a specific graph, how many arithmetical structures does it have and what can you say about their structure. It was proven by Dino Lorenzini that any graph has a finite number of arithmetical structures, and there already exists an algorithm for computing all arithmetical structures for both paths (non-branching, non-cyclic graphs) and cycles (non-branching graphs). In this talk, we look at more complex graphs and find algorithms and patterns for computing each graph's arithmetical structures. More complex graphs include those with branching and also those with multiple connections between the same points. In particular, graphs with a single vertex of degree three will be analyzed.

4:20–4:35

Hamilton Cycles in k-partite Graphs

Robert Krueger
Miami University

One major question of graph theory is which graphs have Hamiltonian Cycles, cycles that traverse every vertex of the graph exactly once. In particular, many people have investigated what conditions imply this property of Hamiltonicity. Dirac first showed that if the minimum degree (the number of edges coming from a vertex) of a graph is at least half the number of vertices, then the graph contains a Hamiltonian cycle. Similar *degree conditions* have been created for balanced k-partite graphs (where the vertices are divided into k disjoint equally sized parts). We extend these results to not-necessarily balanced k-partite graphs. In the talk I will give an overview and history of the problem (suitable for an audience without much graph theory experience), some insight into the generalization, and if time permits an outline of our proof.

4:40–4:55

On Decomposing the Complete Symmetric Digraph into Orientations of $K_4 - e$

Brian D. Darrow, Jr.
Southern Connecticut State University

In graph theory, the *complete symmetric digraph of order* n, denoted by K_n^*, is the digraph on n vertices with the arcs (u, v) and (v, u) between every pair of distinct vertices u and v. For a digraph H, let $E(H)$ denote the arc set of H, and let D be any of the 10 digraphs obtained by orienting the edges of $K_4 - e$ (K_4 less an edge). A *D-decomposition* of a digraph H is a set $\Delta = \{D_1, D_2, \dots, D_r\}$ of pairwise arc-disjoint subdigraphs of H, each of which is isomorphic to D such that $E(H) = \bigcup_{i=1}^{r} E(D_i)$. A D-decomposition of K_n^* is also known as a *(K_n^*, D)-design*. In our research, we establish necessary and sufficient conditions for the existence of a (K_n^*, D)-design for 8 of the aforementioned digraphs (orientations of $K_4 - e$). Partial results as well as some nonexistence results are established for the remaining 2 digraphs.

5:00–5:15

A Two-Stage Vehicle Routing Algorithm Applied to Disaster Relief Logistics after the 2015 Nepal Earthquake

Stephanie Ann Allen
State University of New York at Geneseo

Operations research models can enable users to find more efficient ways of distributing supplies to areas affected by natural disasters. After the 2015 Nepal Earthquake, the Himalayan Disaster Relief Volunteer Group (HDRVG) distributed supplies to affected areas and, during this distribution, the organization kept detailed records of its missions and made the information public. In this project, we model the organizations delivery of supplies to areas in need as a vehicle routing problem, whereby we seek to find the quickest way of routing the delivery vehicles to the locations the organization identified with the restriction that each location is serviced by one vehicle. The vehicle routing problem has an extensive literature regarding possible modeling and solution techniques. We focus on a two-stage method proposed by Fisher and Jaikumar which first allocates locations to vehicles via an integer program and then routes the vehicles according to specific algorithms. In the allocation stage, we use the assignment problem formulation to assign locations to vehicles. In the routing stage, we implement multiple heuristics for the sake of comparison. We present the results of this two-stage method for each of the 26 days during which the HDRVG distributed supplies. Our results illustrate the computational necessity of heuristics for and the open nature of the vehicle routing problem.

5:20–5:35

Some Results on Coloring Interval Hypergraphs

Sarthak Mishra
Troy University

"Let vertex set $X = \{x_1, x_2, \ldots, x_n\}$, and let $\mathcal{C} = \{C_1, C_2, \ldots, C_l\}$ and $\mathcal{D} = \{D_1, D_2, \ldots, D_m\}$ be families of subsets of X, called $\mathcal{C}$-edges and $\mathcal{D}$-edges, respectively. Then the triple $\mathcal{H} = (X, \mathcal{C}, \mathcal{D})$ is said to be a mixed hypergraph. A proper coloring of $\mathcal{H}$ is an assignment of vertices into a set of colors such that every $\mathcal{C}$-edge has at least two vertices of a Common color and every $\mathcal{D}$-edge has at least two vertices of a Different color. The minimum (maximum) number of colors that can be used in a proper coloring of $\mathcal{H}$ is the lower (respectively, upper) chromatic number of $\mathcal{H}$, and is denoted by $\chi(\mathcal{H})$ (respectively, $\overline{\chi}(\mathcal{H})$).
If $\mathcal{C} = \mathcal{D}$, then $\mathcal{H}$ is called a bi-hypergraph. If there exists a linear ordering of the vertices of a bi-hypergraph $\mathcal{H}$ such that every edge induces an interval in this ordering, then $\mathcal{H}$ is a mixed interval (bi)-hypergraph. Consider such an $\mathcal{H}$ on n vertices where every three consecutive vertices are a $\mathcal{C}$ and $\mathcal{D}$ edge. For $i = 2, \ldots, \overline{\chi}(\mathcal{H})$, let r_i denote the number of proper colorings of $\mathcal{H}$ with i colors. Among other results, we determine a formula for r_2.

5:40–5:55

Generalizing The Combinatorial Proofs of Identities Involving Sums of Powers of Binomial Coefficients

Phuc Nguyen
Marquette University

In their paper, John Engbers and Christopher Stocker provided a combinatorial proof for the identity

$$\sum_{i=0}^{n} \binom{i}{r}^{s} = \sum_{k\geq 0} \left\langle {\mathbf{m} \atop k} \right\rangle \binom{n+k+1}{rs+1}$$

where $r, n,$ and s are nonnegative integers with r fixed. Based on their work, we will extend the previous identity where we have arbitrary nonnegative integers $r_1, r_2, \ldots, r_s$ in the lower parts of the binomial coefficients, that is, we will prove the identity

$$\sum_{i=0}^{n} \binom{i}{r_1}\binom{i}{r_2}\cdots\binom{i}{r_s} = \sum_{k\geq 0} \left\langle {\mathbf{m} \atop k} \right\rangle \binom{n+k+1}{r_1+r_2+\cdots+r_s+1}.$$

We then further extend this problem even more by providing a formula for the sum

$$\sum_{i=j}^{n} \binom{i}{r_1}\binom{i}{r_2}\cdots\binom{i}{r_s}$$

where the index i starts from an integer j not necessarily 0 like in the previous case.

6:00–6:15

Adaptive Strategies in Poker-like Games

Ruoyu Zhu
University of Illinois at Urbana-Champaign

We begin by describing John von Neumann's mathematical model of poker and its subsequent generalizations by others. Focusing on some specific extensions of the von Neumann model, we use the technique of "level-k modeling" to develop adaptive strategies in multi-round poker games. Players adapt their strategies based on observations of their opponent's behavior in the previous rounds. Furthermore, we illustrate our theoretical results by simulating different strategies and skill levels interact in multi-round games.

Conference Room 4D **4:00P.M. – 5:55P.M.**

4:00–4:15

Auxiliary Conditions to the Euler-Lagrange Equations for a New Class of Non-Standard Lagrangians

Niyousha Davachi
University of Texas at Arlington

A new class of non-standard Lagrangians that explicitly depend on the special functions of mathematical physics is discovered and this requires adding some auxiliary conditions to the Euler-Lagrange equations. Several examples with applications of the new non-standard Lagrangians are presented and discussed. Moreover, the relationships between the obtained results and Lie algebras and Lie groups are also briefly addressed.

4:20–4:35

A Blast from the Past: Finding Chaotic Solutions to Differential Delay Equations

Erik L. Wendt
Gettysburg College

We summarize some key properties of differential delay equations of the form

$$x'(t) = f(x(t - d(x_t))),$$

which are known as state dependent differential delay equations. We present some new results on finding chaotic solutions to such equations.

4:40–4:55

Get Rid of Math Anxiety in Ten Stages

Ashraf Demian
Texas State University

Anxiety about mathematics is tied to low grades in courses and low scores on standardized tests, yet not all math-anxious individuals perform equally poorly in math. In particular, there are several other factors that create troubles for those that worry about mathematics. The good news is that there is a technique for addressing math anxiety. The solution described in this presentation contains ten steps, such as analyzing the problem and providing a helpful strategy for those who do not feel comfortable with mathematics. Our presentation will be of interest and use to professional mathematics educators.

5:00–5:15

Using Tiered Modeling Problems As a Math Pedagogical Tool in Secondary Education

Taylor R. Stacey
Augustana University

Mathematical modeling applies the robust complexity of mathematics to express real-world phenomena and to analyze its results. We considered mathematical modeling done in the high school setting; including in-depth definition of mathematical modeling, tiered sets of real life modeling problems, lesson plans for the teachers coupled with assessments. The benefit from mathematical modeling for students is that they can apply the iterative problem solving process they develop to areas of interest that need further explanation or can be simplified through modeling.

5:20–5:35

4C Coding in STEM- Identifying Obstacles to Clear Scientific Writing by Analyzing the Relationship Between Assignment Complexity and Students Quantitative Writing Ability

Erika Sweet
Santa Clara University

Many people stereotypically characterize mathematicians as bad writers. Is that true? Or is it that the complexity of quantitative information makes it difficult to write well? To answer this question, we created a simple method (4C coding) to objectively measure quantitative writing and transform it into a matrix of boolean presence/absence features. Each feature represents one element of a written statement that is necessary to communicate quantitative data. We can interrogate the "4C" matrix to test hypotheses about the relationship between student writing ability and factors such as academic performance, assignment complexity, demographic information and conceptual knowledge. Preliminary analyses have found an inverse relationship between 4C writing scores and numerical complexity. That is, the number of values presented in a problem can negatively impact writing ability. We stratified students based on overall performance in the course and evaluated the impact of numerical complexity on writing. At low numerical complexity, there is no statistical correlation between students performance in the class and writing ability (ANOVA3, $p = 0.185$). However, when numerical complexity increased, students in the higher strata scored 28 percent higher than lower performing students, suggesting that different students may be differentially impacted by numerical complexity (ANOVA1, $p = 0.0146$). We plan to determine other factors that impact students resilience to numerical complexity and develop a computational model that describes the elements that contribute to complexity.

5:40–5:55

Optimizing Refuse Collection Routes in Huntington, WV

Steven M. Rollins
Marshall University

The City of Huntington Public Works Department uses 6 garbage trucks to collect garbage for 15,768 customers over 5 zones every week (30 total routes). Within these zones, the tonnage collected on each route is unequal resulting in premature commutes to dumping sites and imbalanced workloads for each truck. This may be the result of demographic shifts that have rendered existing routes heavier or lighter than in the past. In this talk, we will discuss the processes of collecting data, modeling garbage production, and developing an optimization routine with the ultimate objective of balancing these routes.

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

4:00–4:15

The Mathematics of SET

Jessie M. English
The University of Texas at Tyler

SET is a card game which requires cognitive, logical, and spatial reasoning skills to complete a *set.* A *set* is a group of three cards which are either all the same or all different in four distinct features: shape, shading, number, and color. The game of SET has connections to a variety of topics in mathematics, including counting, probability, modular arithmetic, and geometry. We will discuss some of these connections while improving our own game strategy.

4:20–4:35

The Dynamics of Predator-prey Models in A Lake Environment

Simon Deng
University of Nebraska-Lincoln

In this paper, we explore the dynamics of predator-prey models in the lake environment. We separate the lake into two depth levels for prey to live in and assume predator species live above the lake. In these models, we assume logistic growth for the prey in the surface level of the lake and no birth for the prey in the bottom level of the lake. Then we consider three different types of recruitment for predators and hence create three different predator- prey models. The purpose of this study is to examine how factors such as lake depth affect populations of both predator and prey. We discuss the stability and instability of the equilibrium solutions and provide numerical simulations to graphically demonstrate the population dynamics of the system.

4:40–4:55

What Bird Was That? Feature Extraction of Recorded Bird Songs for Neural Networks

Sarah Jean Seckler
Hope College

In the past, researchers at Hope have worked towards identifying birds from recorded bird songs through using wavelets, image processing and neural networks.The general aim of our project is to extend this work to provide greater computational efficiency and accuracy in identification of bird songs. In this talk I will focus on taking a recorded bird song signal and extracting data from it to make it a suitable input for a neural network. This feature extraction process will involve using wavelets and related methods to create an image called a scalogram, encoding the key aspects of the sound including frequency and time. Our work focuses primarily on finding more efficient ways to extract these images, allowing us to analyze much larger data sets.

5:00–5:15

Name That Bird! Using Neural Networks to Identify Bird Songs

Russell P. Houpt
Hope College

Can a computer learn to identify a bird by analyzing samples of its song? This research explores how neural networks can be used to identify different birds from recordings of their songs. In this talk, we will explore what neural networks are, how they work, and what techniques were employed to teach the programs how to quickly and accurately identify birds. In earlier work, a research group at Hope College made progress on this question by using neural networks to classify bird songs on a somewhat limited scale. Our results extend this work by using similar techniques on larger data sets, improving the accuracy and speed of the analysis, and modifying the existing algorithms to take advantage of multiple core computers.

5:20–5:35

Fluid Dynamics of Red Blood Cell Transport in Capillaries Predicts Optimal Throughput

Jie Zhang
UC Irvine

Red blood cells (RBCs) must move throughout our bodies to deliver oxygen. RBCs are around 8 microns in diameter, while capillaries (the smallest part of our circulatory system) are around 6 microns in diameter, so these cells must squeeze. Previous researchers have used computational fluid dynamics to understand RBC transport, including squeezing in capillaries. However, in humans, RBCs make up around 40 percent of blood by volume, therefore they do not just interact with capillaries but with each other too. This leads to a particularly challenging fluid-structure fluid dynamics problem. Here, we develop a computational fluid dynamics simulation based on the immersed boundary method with a novel scheme for periodic boundary conditions. We simulate multiple RBCs in a capillary. We find that the more crowded the capillary, the slower the RBCs flow. Surprisingly, there is significant slowdown even far below the crowding limit (100 percent of volume fraction). This slowdown is due to a long-range interaction between RBCs mediated by the fluid. Therefore, the throughput of RBCs exhibits a maximum with respect to RBC density. Even more surprisingly, the optimal throughput occurs at around 40 percent of volume fraction, similar to the value in humans. We speculate that the RBC density in humans is optimized for maximum throughput through capillaries.

5:40–5:55

Modeling Assortative Mating; Creating Configurations of Conflicting Counterparts

Lydia M. DeMorett
College of Saint Benedict/Saint John's University

Studies show that individuals display preferences when choosing a mate. Assortative mating models take into account the organisms' preferences versus a random mating model which, while computationally easier, is less realistic. This study uses Markov chains to create a flexible model to analyze long term effects of different types of assortative mating. Previous models considered strictly positive or strictly negative assortative mating. We investigate when positive and negative assortative mating are combined.

6:00–6:15

Using a Mathematical Model to Explain the Role of Patterned Neural Input on a Rhythmic Oscillatory Network

Madel Roque Liquido
Saint Peter's University

In the nervous systems of animals, the electrical output of oscillatory neural networks is strongly influenced by input from descending projection neurons. However, due to their complexity, the synaptic interactions that affect oscillatory networks are not well-understood in most systems. We examine this issue in a simplified mathematical model of the gastric mill (chewing) oscillatory network in the stomatogastric ganglion (STG) of the crab, Cancer borealis. Our model is based upon data from the biological system, where the modulatory commissural neuron 1 (MCN1) is a projection neuron that activates a gastric mill rhythm (frequency 0.1 Hz). By using the difference in synaptic time scales that is inherent in the biological system, we mathematically reduce our model down to 2 dimensions and perform a phase plane analysis of the network oscillations. We find that the slow pattern of neural input from MCN1 axon terminals to the lateral gastric (LG) neuron, within the STG, controls the frequency of the network oscillations. In particular, the buildup of MCN1 input in the LG neuron controls the duration of the LG interburst phase. Conversely, the decay of MCN1 input, due to LG presynaptic inhibition of MCN1, controls the duration of the LG burst phase.

Conference Room 4C **8:30A.M. – 11:45A.M.**

8:30–8:45

Evaluating Kostant's Multiplicity Formula

Elise Eckman
Youngstown State University

Central to the study of the representation theory of Lie algebras is the computation of weight multiplicities, which are the dimensions of vector subspaces called weight spaces. The multiplicity of a weight can be computed using a well know formula of Kostant that consists of an alternating sum over a nite group and involves a partition function called Kostant's partition function. There are two major obstacles in the use of this formula. First, the number of terms arising in the sum grows factorially as the rank of the Lie algebra increases and, second, the value of the partition function is often unknown. The focus of the presentation is on the Lie algebra slr+1(C) and questions regarding the number of terms contributing nontrivially to Kostant's weight multiplicity formula. These contributing sets, called Weyl alternation sets, show interesting combinatorial and geometric properties.

8:50–9:05

Induced Representations

Monica Ellen Busser
Youngstown State University

In this talk we will define the basic concepts of Representation Theory and prove essential results about representations. We will then discuss what it means for a representation to be irreducible and the importance of irreducibility to the study of representations. The representations we will look at in particular are called induced representations. We will show that inducing a certain subgroup, called the Borel subgroup, to the general linear group of two by two matrices with entries from $\mathbb{Z}_2$ of the trivial representation yields a new representation that is not irreducible.

9:10–9:25

Periodic Points of Tent Maps

Marleah Roseman
SUNY Fredonia

For integers m and n with $0 < m < n$ and m and n relatively prime, we consider the function on $[0, n]$ whose graph consists of the segments from $(0, 0)$ to (m, n) and (m, n) to $(n, 0)$. We consider the problem of finding periodic points of this function.

9:30–9:45

The Flip and Horseshoe Shuffles Through Dynamical Systems

Annie Small

Juniata College

The flip shuffle and the horseshoe shuffle are newly explored ways of shuffling cards. Both shuffles are performed by splitting a deck of cards into two piles. The bottom pile is flipped over and the cards are interlaced in an alternating sequence. The flip shuffle cares whether the cards are face up or face down, whereas the horseshoe shuffle does not. By modifying a model for the perfect shuffle, we create a new model for the flip and horseshoe shuffles to determine the orbit, the prime period, and the itinerary of a card under the flip and horseshoe shuffles.

9:50–10:05

Minimizing Positive Integer Sequences Without Duplicate Substrings

Joseph S. O'Brien

Southern Connecticut State University

In this presentation, we explore minimizing the integer produced by a binary operation on the elements of a positive integer sequence containing no duplicate substrings. Here, a substring is a subsequence of consecutive elements. We present results for minimizing under binary operations such as the Least Maximum Integer (LMI), Least Common Multiple (LCM), Sum and Product, leading to a generalized process for a large class of monoids applied to the elements of a sequence of length n.

10:10–10:25

The Probability of Generating an Abelian Group

Noah Dane Froberg

St. John's University

Previous research has found a formula for the probability of two distinct, random elements of an abelian group generating the group when the group needs two generators. We will generalize this formula to abelian groups needing more than two generators.

10:30–10:45

Characterizing Monomial Galois Groups of Homogenous Differential Equations of Prime Order

Jack Wagner
Armstrong State University

Differential Galois theory is a relatively new field of mathematics, which integrates many disciplines, including not only abstract algebra and differential equations, but also topology, linear algebra, and representation theory. In this talk, we will introduce the basic elements of differential Galois theory while making connections to the more familiar Galois theory of polynomials. Our current work deals with the case when a differential equation has a monomial Galois group. In the spirit of earlier work of J. Kovacic, M. Singer, and F. Ulmer, we begin by understanding the form of such groups and their representations. We then make use of a correspondence between reducibility properties of group representations and factorization of associated linear differential equations in order to investigate implications on the solutions of the differential equation.

10:50–11:05

Squaring Off: The Quadratic Formula in an Arbitrary Field

Kristen Kaylene Reihl
University of Mount Union

The formula for solving an equation of the form $ax^2 + bx + c = 0$ where a, b, and c are real numbers with $a \neq 0$ is widely known as the quadratic formula. Several methods exist for deriving the quadratic formula, $x = (-b \pm \sqrt{(b^2 - 4ac)})/(2a)$, in the traditional secondary mathematics classroom. What many are less-familiar with is the formula for solving such an equation where a, b, and c are elements of a more abstract algebraic system. This talk will explore quadratic equations in an algebraic system called a field and how the quadratic formula is derived in such a field.

11:10–11:25

Congruence on Inverse Semigroups

Yansy E. Perez
University of Texas at Tyler

An inverse semigroup is a semigroup S such that for every s in S there exists a unique s^* such that $s = ss^*s$ and $s^* = s^*ss^*$. A congruence on an inverse semigroup is an equivalence relation that is compatible with multiplication. Congruences play a role in inverse semigroup theory that is similar to the role of normal subgroups in group theory. We study the congruences in various classes of inverse semigroups including the inverse semigroups of directed graphs and the inverse semigroups of self-similar graph actions. We classify the inverse semigroups for which all homomorphisms are achieved by modding out by an ideal. We characterize this property for inverse semigroups of self-similar graph actions and describe the ideals.

11:30–11:45

Discrete Boundary Problem via Integro-differential Algebra

Sieu K. Tran
Virginia Tech

The notion of integro-differential algebra was introduced to facilitate the algebraic study of boundary problems for linear ordinary difference equations. In this study, we construct a discrete analog in order to investigate boundary problems for difference equations. Key properties of the (discrete) integro-differential algebra are proven, including the discrete analog of the variation-of-constants formula. Our next goal is to build up an algorithmic structure for specifying difference equations and the boundary conditions, and to solve them via integro-differential operators. We have written the relations between these operators in the form of rewrite rules, constituting a Noetherian and confluent reduction system or a noncommutative Groebner basis for the relation ideal of the operator ring. We derive the normal forms modulo this reduction system for every discrete operator and every boundary condition. We conclude with a discrete analog of an ill-posed boundary problem from which we extract its Green's function.

Conference Room 4D **8:30A.M. – 11:45A.M.**

8:30–8:45

A New Method For Computational Analysis of High-Speed Gas Flows

Michael Pearce
St. Olaf College

Modeling high-speed gas flows is valuable for the development of hypersonic flight, aerospace, and combustion technologies. High-speed gas flow behaves differently than low-speed flow, and is not currently well understood. To study these flows, a method called Molecular Tagging Velocimetry (MTV) is used. MTV works by exciting seeded gas molecules with a laser, making their movement visible and quantifiable. Using multiple lasers, this process creates a laser "grid" of fluorescent gas that can be tracked over time. However, current methods of tracking this laser grid - and thus the high-speed gas flow - are limited in both accuracy and resolution. We propose a new, computational method to analyze MTV data based on the Hough transform, a method of line detection and parameterization. Using the Hough transform to accurately parameterize the movement of the laser grid over time allows for the quantification of the gas flow. Furthermore, the method utilizes a variety of k-Nearest Neighbor algorithms and linear algebra techniques to increase precision of the gas flow quantification. The result of this method is a dense vector field mapping the motion of high-speed gas flows over time.

8:50–9:05

Newton's Method on Rational Functions in the Complex Plane

Travis A. Howk
Hendrix College

Past research has examined the chaotic dynamics of polynomial functions under Newton's Method in the complex plane. We expand upon this research by exploring he dynamics of Newton's Method for rational functions with real roots over the complex plane. We establish domains of interest for several classes of rational functions outside of which all behavior is homogeneous. In addition, we examine a phenomenon coined "kaleidoscoping" in which certain regions in the complex plane act as non-converging sinks.

9:10–9:25

Most Economical Common Dissection of a Square and Equilateral Triangle

Trent DeGiovanni
Gonzaga University

The Wallace-Bolyai-Gerwien theorem states any polygon can be decomposed into a finite number of polygonal pieces that can be translated and rotated to form any polygon of equal area. The theorem was proved in the early 19th century. The minimum number of pieces necessary to form these common dissections remains an open question. In 1905, Henry Dudney demonstrated a four-piece common dissection between a square and equilateral triangle. We investigate the possible existence of a three-piece common dissection. Specifically we examine possible dissections in which all of the polygonal pieces are convex.

9:30–9:45

On The Algebra of Rotations in $\mathbb{R}^3$:
An Exploration of Representations by Quaternions and $SU(2)$

Nicholas P. Meyer
Winona State University

The need to represent rotations of objects in 3-D Euclidean space arises daily in many fields: animation, computer vision, and physics, to name a few. Ever since Euler first described his eponymous angles, without giving a tractable method for constructing them, mathematicians have longed for a better system to describe rotations. In 1843, William Rowan Hamilton had an epiphany whilst walking across Brougham Bridge in Dublin with his wife. Therein he inscribed the laws defining the quaternions, forever changing the face of rotations. The quaternions, when limited to having unit norm, form a group under multiplication which is isomorphic to SU(2). This presentation will discuss the interplay between these two groups and will clarify the use of quaternions to represent rotations. We will delve into the relationship between SU(2) and SO(3).

9:50–10:05

Extending the Bôcher-Grace Theorem to Quadrilaterals and other Polygons

Callie A. Sleep
South Dakota State University

In recent years several published papers have investigated ellipses inscribed in triangles in the complex plane and related the geometry of the ellipse to a polynomial whose zeros are the complex coordinates of the vertices of the triangle. The foci of the ellipse are then the zeros of the derivative of this polynomial. In 2008, Dan Kalman revisited this result that had not been discussed in the mathematical literature for 59 years. He called the result 'the most marvelous theorem in mathematics'. We call this the Bôcher-Grace Theorem after two early authors who discussed this result. The purpose of this undergraduate research project is to extend this type of result to quadrilaterals and other polygons.
Since then several papers have been published with alternate proofs and extensions of the result to quadrilaterals and other polygons. These papers are accessible for expansions and research to undergraduate mathematics students who are familiar with complex numbers, linear algebra and geometry. This research has opened up more ideas within the fields of complex numbers and geometry. For instance, the connection between convex polygons and inscribed ellipses involves Chebyshev polynomials of the first kind of degree n. With more research, we are able to expand our own knowledge and further investigate the ideas put forth. Therefore, we will more thoroughly understand the interworking of geometry and how different shapes and figures interact.

10:10–10:25

Some Congruence Criteria for Quadrilaterals and Higher Polygons

Uttam Bhetuwal
Troy University

In high school geometry, one typically learns congruence criteria theorems for triangles, such as ASA, SSS, SAS, and AAS, along with perhaps some specialized theorems for right triangles. A natural question is: What congruence criteria exist for n-gons for $n > 3$? We answer this question for $n = 4$ (quadrilaterals), and show some results for $n > 4$.

10:30–10:45

From Phylogenetics to Statistical Physics:
Tensor Wiring Diagrams and the Impact of Tensors on the Sciences

Parth Sarin
Texas A&M University

Due to their usefulness in organizing data, tensors are used in almost every scientific discipline. Applications aside, tensors also give rise to beautiful geometric structures. To understand them, mathematicians use wiring diagrams. Dating back (at least) to Clifford in 1881, these diagrams provide a powerful realization of many complex tensors, aiding in our understanding of their structure, applications, and geometry. Well discuss tensor wiring diagrams and the application of tensors to phylogenetics and/or algebraic statistics, time permitting.

10:50–11:05

Survey of the Theory of Tensors

Kevin Smith
University of California, Irvine

Due to the coupling with Manifold Theory, tensors find a large number of applications in both modern science and pure mathematics. Some examples are in the study of Elasticity, Fluid Mechanics, General Relativity in physics and Linear Algebra, Geometry, Topology, and P.D.E.'s in math. The applications usually take the focus away from what a tensor actually is and how one should properly use them. Spanning several great texts on the subject at the graduate level, the subtleties of definition and manipulation have been extracted and compiled into a short text presentable at the undergraduate level. Topics range from the construction of general tensors to vector bundles, symmetric and skew-symmetric products, transformation laws and even calculus on manifolds.

11:10–11:25

Explicit Origami Constructions of Regular Polygons

Kiersten Potter
Marshall University

It can be shown algebraically that certain polygons can be constructed by origami. However, developing the method of construction is more complex. We aim to detail construction of basic polygons and then show how bisections and trisections can be utilized to extend those construction methods to higher n-gons.

11:30–11:45

Discovering Parallels Between Euclidean Constructions and Origami Constructions

Michelle Emily Persaud
SUNY Fredonia

"What can we construct using origami?" This is similar to the question, "What can we construct using a straight edge and compass?" Euclid made the first attempt to axiomatize compass and straight edge constructions approximately 2500 years ago in his series of works, The Elements. 19th Century mathematicians used algebra to provide a framework for determining what is and is not constructible. Recently, mathematicians have used an isomorphic axiomatic and algebraic approach to determine what is foldable using origami. The goal of this presentation is to demonstrate how origami constructions can be axiomatized, and to determine what restrictions someone would face when creating an origami construction.

Conference Room 4K **8:30A.M. – 11:45A.M.**

8:30–8:45

No Talk

8:50–9:05

Calculating Risk Versus Reward: The Use of Game Theory in Business and Economics

Rebecca M. Cooper
University of Mount Union

Both game and economic theory play a large role in business-related decision-making. These theories have grown from an obscure concept of the 1960's to a mainstream method of quantifying and manipulating human behaviors to achieve a certain outcome. Game theory has been successfully applied in matching situations such as business-to-consumer and business-to-business markets, as well as to management's decision-making. While it has been very useful in these subfields, game theory has been unsuccessful in bargaining and in scenarios in which multiple equilibria exist. This research seeks to further analyze the mathematics that have helped develop game theory into a successful economic tool.

9:10–9:25

The Iowa Democratic Caucuses: A Mathematical Analysis of the "Vote"

Brandon Payne
Elmira College

Kenneth Arrow pioneered the field of mathematical voting theory by critiquing election systems based on certain "fairness criteria." Since 1972, Iowa voters have been the first to vote for presidential candidates during the busy primary election season. This paper defines nine of these criteria to analyze the properties of the Iowa Democratic Caucuses at the precinct level, before analyzing how apportioning delegates to the county level caucuses can change the outcome of the election. The requirement that all preference groups must be viable before a caucus can end, the precinct in which a caucus-goer attends, and the number of delegates each precinct elects are additional factors that influence whether or not the Iowa Democratic Caucuses can be considered a fair election system.

9:30–9:45

An Analysis of Quantitative Measures for Detecting Gerrymandering

Ngan N.P. Tran
Ripon College

Gerrymandering is intentional manipulation of voting districts that is carried out for political gain of one party over another. Nonpartisan scholars have shared concerns that gerrymandering is a substantial risk to representative democracy, especially in an increasingly polarized political environment. Early attempts to quantify gerrymandering have produced several measures of compactness and geographic information technologies. Other analyses carry out statistical tests that use nationwide election outcomes instead of maps to access asymmetry in state-level districting schemes in order to detect gerrymandering. This project analyzes and compares one of the measures proposed by Samuel Wang in the Stanford Law Review with other quantitative methods for identifying gerrymandering.

9:50–10:05

Hackenbush: A Glimpse into Combinatorial Game Theory

Candyce Sarringar
Hendrix College

In this paper, Combinatorial Game Theory is explored as it pertains to the game Hackenbush. The goal of the game is to be the player that moves last. The versions of the game analyzed are Red-Blue Hackenbush and Red-Blue-Green Hackenbush. These games by their very nature often split into a sum of smaller games. To assign a value to each game, then, amounts to defining a homomorphism v from the commutative monoid of games to a commutative monoid of numbers. That is, we seek a function $v : \{\text{games}\} \to \{\text{numbers}\}$ such that $v(G + H) = v(G) + v(H)$ for all games G and H. During this search, we used the Tweedledee-Tweedledum Principle, analyzed Strings and Trees and proved the Replacement Theorem. To deal with Red-Blue-Green Hackenbush games, surreal numbers had to be invented.

10:10–10:25

The Mathematics of Poker: Measuring Skill and its Effect

John Augustus Haug
University of Illinois in Champaign-Urbana

Working primarily with poker models described by John von Neumann and subsequent extensions by others including noted World Series of Poker Champion Chris Ferguson, we attempt to quantify personal skill against luck and determine its relationship to the outcome of various poker games. By considering different skill levels and sub-optimal strategies, we can create a more realistic and useful analysis, as compared to the optimal strategies for both parties assumed in the von Neumann analysis. We investigate these effects using computer simulations and theoretical analysis and determine just how much skill is required to profit in the long run.

10:30–10:45

Helping Students Make Wise Data Driven Academic Decisions

Lexi Elaine Rager
Youngstown State University

With the rapid growth of technology in todays world, people are faced with thousands of decisions every day, especially online. Information filtering systems sort through the appropriate data and return, on an individual basis, only the most relevant sources. A specific subclass of information filtering systems called recommender systems strives to uncover and interpret implicit and explicit information from users, incorporate the new material into the previous body of information on that user, and use all of the existing data to predict the preferences of the users in the most accurate way possible. This has become a widespread tactic for companies in recent years who want to create a personalized experience for their customers. For example, social media may suggest people you may know based off of your other friends. Netflix may recommend similar shows to you based off a show you just finished watching, and online dating sites might propose matches based on elements of your online profile. Our research explores the different types of recommender systems and the strengths and weaknesses of each. After compiling and modifying such systems, we apply our algorithm to help students navigate the intricacies of college academic decisions.

10:50–11:05

Surprising Nontransitive Games

Christine C. Langer
Youngstown State University

If A beats B and B beats C, then A should beat C, correct? This is not always the case; there are several scenarios in which C beats A. We will explore games with this nontransitive quality, calculate related probabilities, and analyze the mathematics behind them.

11:10–11:25

Equivalency of Easter Algorithms

Emily Simon
St. Norbert College

The algorithm used to determine Easter in the Gregorian calendar was formulated in the 1500's in Latin, using ancient mathematical tools such as epacts and golden numbers. The algorithm has been reformulated and modernized several times over the centuries, most famously by Gauss. We exhibit several algorithms for determining the date of Easter and show why they are equivalent.

11:30–11:45

Properties of the Easter Cycle

Dayle Duffek
St. Norbert College

The date of Easter is mathematically determined by approximations to the solar, lunar, and hebdomadal cycles. We study the function which maps each year to the date of Easter in that year, according to the Gregorian calendar, and describe patterns and properties of this function.

International Ballroom South **8:30A.M. – 10:30A.M.**

Opportunistic Rebalancing

Alana Danieu, Emily Kaegi, Annie Shapiro, and Daniel Weithers
Carleton College

Determine an optimal stock portfolio rebalancing strategy based on historical market performance.

A Mathematical Model based on IC50 Curves to Predict Tumor Responses to Drugs

Catherine Berrouet, Jake Nadulek, Sunil Giri, and Emmanuel Fleurantin
Florida Atlantic University

The standard measure of the drug dose needed to kill (or inhibit the growth of) half of the tumor cell population is called the IC_{50} concentration. To determine the IC_{50} value, the cells are grown for 72 hours (or 96 hours) in separate dishes, each with the increasing concentrations of the drug. However, in the Petri dishes all cells are equally well exposed to the drug. The goal of this project is to develop a mathematical model to investigate how to use (or improve) the IC_{50} approach to control the growth of 3D tumors.

Classifying Queries Based on the North American Product Classification System (NAPCS)

Ashley Sexton and Tianna Burke
Howard University

Every five year the US Census Bureau conducts a census of the goods and services available in the country. An important challenge in this task is to provide the producer and consumer with quick and accurate access to information they might require. The aim of this project is to classify words and phrases that fall into specific categories based on the North American Product Classification System.Using vector representation we devised several ranking algorithms to find the best categories for a given word/phrase.

Ensuring the Insurer: A Modern Statistical Approach to Estimating Unpaid Losses

Laura Farro, Courtney Taylor, and Matthew Gallatin
Northern Kentucky University

This project details a modern statistical approach to estimating loss reserves. Working with data sets supplied by American Modern Insurance Group, new models are developed and tested against standard actuarial techniques.

Assembly Line Efficiency at a Large Manufacturing Plant

Levi Nicklas and Jacob Kautz
Shippensburg University

Develop a mathematical model, and associated computer-based tool, to identify efficient assembly line structure at a large construction manufacturing facility.

Predicting Customer Insurance Type

Megan Sharp, Benita Beale, and Matthew Lyons
University of Washington, Tacoma

A health insurance company has a large dataset from a survey including health insurance plan, demographics, media habits, and many other variables. They would like to understand common characteristics of healthcare consumers—is there a way to segment these consumers based on criteria that could help the healthcare company make marketing and strategy decisions?

Profit Optimization

Quinn Burzynski, Lydia Frank, Zac Nordstrom, and Jack Wolfe
University of Wisconsin, La Crosse

The students analyzed past quoting data for a local industrial parts supplier. They utilized machine learning techniques to identify most significant factors for quoting success. They discovered optimal discounts per product categories to maximize profit when selling to new customers.

Analyzing New Health Care Placement of Mercy Health Facilities

Natalie Halavick, Leah McConnell, Khang Nguyen, and Sara OKane
Youngstown State University

Mercy Health asked for recommendations regarding the placement of a new inpatient or outpatient health care facility in the Youngstown area. Given data on health care utilization and projections for health care usage for the next five years, the students developed a model and provided potential locations and lines of service for such a facility.

J. Sutherland Frame Lectures

2017	Ingrid Daubechies	*Bones and Teeth: Analyzing Shapes for Evolutionary Biology*
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

2017	David Richeson	*Four Tales of Impossibility*
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*
2010	Sommer Gentry	*Faster, Safer, Healthier with Operations Research*
2009	Colm Mulcahy	*Mathemagic with a Deck of Cards on the Interval Between 5.700439718 and 80658175170943878571660636856403766975289505440883277824000000000000*
2008	Laura Taalman	*Sudoku: Questions, Variations and Research*
2007	Francis Edward Su	*Splitting the Rent: Fairness Problems, Fixed Points, and Fragmented Polytopes*
2006	Richard Tapia	*Math at Top Speed: Exploring and Breaking Myths in Drag Racing Folklore*
2005	Annalisa Crannell & Marc Frantz	*Lights, Camera, Freeze!*
2004	Mario Martelli	*The Secret of Brunelleschi's Cupola*
2004	Mark Meerschaert	*Fractional Calculus with Applications*
2003	Arthur T. Benjamin	*The Art of Mental Calculation*
2003	Donna L. Beers	*What Drives Mathematics and Where is Mathematics Driving Innovation?*
2002	Colin Adams	*"Blown Away: What Knot to do When Sailing" by Sir Randolph "Skipper" Bacon III*
2002	M. Elisabeth Pate-Cornell	*Finding and Fixing Systems' Weaknesses: The Art and Science of Engineering Risk Analysis*
2001	Rhonda Hatcher	*Ranking College Football Teams*
2001	Ralph Keeney	*Building and Using Mathematical Models to Guide Decision Making*
2000	Michael O'Fallon	*Attributable Risk Estimation: A Tale of Mathematical/Statistical Modeling*
2000	Thomas Banchoff	*Interactive Geometry on the Internet*
1999	Edward G. Dunne	*Pianos and Continued Fractions*
1999	Dan Kalman	*A Square Pie for the Simpsons and Other Mathematical Diversions*
1998	Ross Honsberger	*Some Mathematical Morsels*
1998	Roger Howe	*Some New and Old Results in Euclidean Geometry*
1997	Aparna Higgins	*Demonic Graphs and Undergraduate Research*
1997	Edward Schaefer	*When is an Integer the Product of Two and Three Consecutive Integers?*
1996	Kenneth Ross	*The Mathematics of Card Shuffling*
1996	Richard Tapia	*Mathematics Education and National Concerns*
1995	David Bressoud	*Cauchy, Abel, Dirichlet and the Birth of Real Analysis*
1995	William Dunham	*Newton's (Original) Method, or, Though This Be Method, Yet There is Madness*
1994	Gail Nelson	*What is Really in the Cantor Set?*
1994	Brent Morris	*Magic Tricks, Card Shuffling and Dynamic Computer Memories*
1993	Richard Guy	*The Unity of Combinatorics*
1993	Joseph Gallian	*Touring a Torus*
1992	Peter Hilton	*Another Look at Fibonacci and Lucas Numbers*
1992	Caroline Mahoney	*Contemporary Problems in Graph Theory*
1991	Lester Lange	*Desirable Scientific Habits of Mind Learned from George Polya*

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