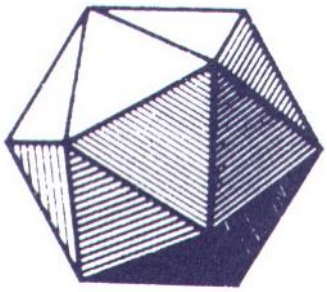
North Central Section

Mathematical Association of America



Fall Meeting • October 15-16, 2021
Virtual Meeting

Friday, October 15, 2021

7:00 – 7:15 **Welcome:** Megan Breit-Goodwin

7:15 – 7:25 **The Hiring Problem: Modifications and Win Strategies**
Chi Tran*, Concordia College, Kayla Selvig, Concordia College

7:30 – 7:50 **Blackout Rows and an Altered Version of the Sieve of Eratosthenes**
Lucus Brady*, Augustana University, Carl Olimb, Augustana University

7:55 – 8:05 **Gradient Descent and Computer Vision**
Thomas Y. Chen, Academy for Mathematics, Science, and Engineering

8:10 – 8:30 **Modeling Climate Change's Impact on Macrocystis pyrifera**
Lauren Mossman*, St. Olaf College, Josey Sorenson*, University of Minnesota, Jose Alanis, Sacramento State University

8:35 – 8:45 **Modeling Housing Prices in the Fargo-Moorhead Area**
Jake Peters*, Concordia College, Alex Voigt*, Concordia College

8:45 – Virtual Social Hour

Saturday, October 16, 2021

Concurrent Session I

Session A

8:00 – 8:20 **Relative Topological Complexity and Configuration Spaces**
Bryan Boehnke*, Carleton College, Shuhang Xue*, Carleton College, Steve Scheirer, Carleton College

8:25 – 8:35 **Heuristics Approach to Solve Stackelberg Game to Mitigate the Spread of Misinformation for Large Real-World Networks**
Katelinh Jones*, Penn State University, Sahana Kargi, University of Utah, Vayam Agarwal, University of Minnesota

8:40 – 9:00 **Getting to the Roots of Fractal Trees**
Jack Krueger, Concordia University

9:05 – 9:15 **Characterization of Rectifiable Measures that are Carried by Lipschitz Graphs**
Yutong Wu*, Macalester College, Charles Zichen Zhang, Macalester College

Session B

8:00 – 8:20 **Triangles, Rhombi, and Hexagons Can Count**
Jed Yang, Bethel University

8:25 – 8:45 **Word Length in Groups**
Tom Sibley, St. John's University/College of Saint Benedict

8:50 – 9:10 **Lights Out on the Hypercube Graph Over the Ring of Integers Modulo k**
Travis Peters*, College of Saint Benedict/St. John's University, James Schwinghamer*, University of Minnesota—Duluth

9:15 – 9:30 Break

Concurrent Session II

Session A

9:30 – 9:50 **Idempotents and Triempotents in Z_n and $Z_{n[i]}$**
Blake Mattson, University of Minnesota—Duluth

9:55 – 10:15 **Standardized Incidence Ratio of the COVID-19 Pandemic: A Case Study in a Midwestern State**
Emma Spors*, South Dakota State University, Semhar Michael, South Dakota State University

10:20 – 10:40 **Capturing Mathematical Knowledge for Teaching Community College Algebra**
Bismark Akoto*, University of Minnesota, Dexter Lim, Tusculum University, Irene Duranczyk, University of Minnesota

Session B

9:30 – 9:50 **Exploring Geometric Converse Problems with GeoGebra**
José N. Contreras, Ball State University

9:55 – 10:15 **Transforming Calculus Discussions with Desmos ~ (and Colab and Github)**
Aaron Wangberg, Winona State University

10:20 – 10:40 **Flipping the Formula in Active Learning Classrooms**
Mike Weimerskirch, University of Minnesota

10:50 – 11:30 Business Meeting

11:30 – 12:00 Lunch Break

12:00 – 1:00 **Invited Talk I:** Catherine (Katy) A. Micek, 3M M&SC – Digitization and Advanced Analytics
The Technical and Organizational Challenges of Data Science

Concurrent Session III

Session A

1:00 – 1:20 **Sequentially Congruent Partitions and Partitions into Squares**
James Sellers, University of Minnesota—Duluth

1:25 – 1:45 **Using Quaternions to Prove Theorems in Spherical Geometry**
Marshall Whittlesey, California State University—San Marcos

1:50 – 2:10 **Estimating Product of Bernoulli Proportions**
Hongyan Hou, Minnesota State University—Moorhead

Session B

1:00 – 2:00 **Panel: The Pandemic's Silver Lining: Improved Instructional Strategies Motivated from a Perturbed World**
Panelists:

- Jeremiah Bartz, University of North Dakota
- Andrew Beveridge, Macalester College
- Suzanne Dorée, Augsburg University
- Julia Walk, Concordia College
- Aaron Wangberg, Winona State University

2:20 – 2:30 Break

2:30 – 3:30 **Invited Talk II:** Aaron Montgomery, Baldwin Wallace University
What are the Odds? A Brief Tour of Counterintuitive Results in Probability

3:30 – 4:30 Estimation Game

Abstracts

Invited Addresses

Catherine (Katy) A. Micek, Data Scientist at 3M – Digitization and Advanced Analytics
The Technical and Organizational Challenges of Data Science

In October 2012 – shortly after I began my career in the data science space – the Harvard Business Review published the article "Data Scientist: The Sexiest Job of the 21st Century" and generated an enormous amount of buzz about the field. Since then, data science has matured: technical skill sets required to do the work are better defined and specializations are emerging. However, the field is still evolving and how data science is used by an organization can vary greatly. In such a dynamic and broadly defined field, it has been my experience that data scientists need to have a wide range of technical skills augmented by soft skills in order to be successful. In this talk, I will share my experience working as a predictive modeler, data scientist, and software developer across various industries (insurance, energy, and within 3M), as well as provide examples of challenges I've encountered as a data scientist. I will also discuss my work on a Digital Solutions Implementation for 3M's Knoxville plant, a project where we are exploring how data science could be used to understand and reduce product variability for Acrylic Foam Tape.

Aaron Montgomery, Baldwin Wallace University
What are the Odds? A Brief Tour of Counterintuitive Results in Probability

The field of probability is rich with questions that are easy to state but have surprising results. One well-known example of this is the so-called "Monty Hall Problem," which famously frustrated even the renowned mathematician Paul Erdös. In this talk, we will assemble a collection of similar questions in probability theory whose answers tend not to match most people's first guess. This talk is intended to be accessible to anyone at any level of mathematics.

Panel

The Pandemic's Silver Lining:
Improved Instructional Strategies Motivated from a Perturbed World
Panelists:

- Jeremiah Bartz, University of North Dakota
- Andrew Beveridge, Macalester College
- Suzanne Dorée, Augsburg University
- Julia Walk, Concordia College
- Aaron Wangberg, Winona State University

The Covid-19 pandemic forced instructors to re-evaluate their teaching strategies and incorporate new instructional techniques. Now, as we emerge from the pandemic, what did we learn? This panel features five instructors who are incorporating these lessons from online instruction into their in-person courses. They will discuss these changes, their benefits, and how they align with the MAA's Instructional Practices Guide.

Contributed Talks

Bismark Akota, University of Minnesota (Graduate)**,**
Dexter Lim, Tusculum University
Irene Duranczyk, University of Minnesota
Capturing Mathematical Knowledge for Teaching Community College Algebra

The Algebra Instruction at Community Colleges 2.0 project seeks to develop, pilot, field test, validate, and disseminate an instrument to measure Mathematical Knowledge for Teaching Community College Algebra (MKT-CCA). We are developing items that will look at two aspects of teaching: Choosing problems and Understanding students' work.

Choosing Problems refers to selecting problem(s) that offer students the opportunity to work on mathematical idea(s). Understanding Students' Work is what the teacher needs to do as an observer and appraiser of students' thinking and work. This session will give an overview of the project and workshop two MKT items.

Bryan Boehnke, Carleton College (Undergraduate),
Shuhang Xue, Carleton College,
Steve Scheirer, Carleton College
Relative Topological Complexity and Configuration Spaces

Given a space X, the topological complexity of X can be viewed as the minimum number of "continuous rules" needed to describe how to move between any two points in X. Given subspaces Y_1 and Y_2 of X, there is a "relative" version of topological complexity, denoted by $TC_X(Y_1 \times Y_2)$, in which one only considers paths starting at a point in Y_1 and ending at a point in Y_2, where the path can pass through any point in X. Here, we present general results that provide relative analogues of well-known results concerning topological complexity and apply them to a special case involving configuration spaces.

Lucus Brady, Augustana University (Undergraduate),
Carl Olimb, Augustana University
Blackout Rows and an Altered Version of the Sieve of Eratosthenes

The distribution of primes has been studied since Euclid, yet discoveries are still being made. The landmark discovery by Terence Tao in 2016 states the existence of infinitely many disjoint real intervals of length at most L that contain two or more prime numbers. Working towards similar results we use sieve theory to identify relative primes to a given window size S. Surprisingly this leads to intervals that contain no relative prime numbers to S, which we call blackout rows. These intervals also have an unknown, symmetric distribution and structure that persist as you change the window size and repeat the sieve. Developing the idea of the characteristic of an interval gives insight into this structure, the distribution of relative primes, and how these blackout rows are entangled with an altered version of the Sieve of Eratosthenes.

Thomas Y. Chen, Academy for Mathematics, Science and Engineering (Undergraduate),
Gradient Descent and Computer Vision for Social Good

The role of gradient descent in deep learning algorithms like convolutional neural networks is key for computer vision applications. In this talk, we discuss how gradient descent and computer vision can be harnessed for social good in real-world applications. We focus on the example of training neural networks on satellite imagery for natural disaster management.

José N. Contreras, Ball State University
Exploring Geometric Converse Problems with GeoGebra

In this presentation, I illustrate how my students and I use GeoGebra to explore geometric converse problems. In particular, we use GeoGebra to gain insight into the solution to the following three problems.

1) Let $ABCD$ be a quadrilateral with medial quadrilateral $EFGH$. If $EFGH$ is a rectangle, what type of quadrilateral is $ABCD$?
2) Let E, F, G, and H be the midpoints of the consecutive sides of a quadrilateral $ABCD$. If $EFGH$ is a rhombus, characterize quadrilateral $ABCD$.
3) E, F, G, and H are the midpoints of the consecutive sides of a quadrilateral $ABCD$. Name quadrilateral $ABCD$ when $EFGH$ is a square.

Hongyan Hou, Minnesota State University—Moorhead
Estimating Product of Bernoulli Proportions

A lower bound of the scaled variance of the product of Bernoulli proportion is estimated. The estimation of convergence rate is up to second order. A two-stage design provides an estimation with a convergence rate less the second order. A three-stage design improves the result to second order.

Katelinh Jones, Pennsylvania State University (Undergraduate),
Sahana Kargi, University of Utah,
Vayam Agarwal, University of Minnesota
Heuristics Approach to Solve Stackelberg Game to Mitigate the Spread of Misinformation for Large Real-World Networks

With the rise in popularity of social media, misinformation has become an increasingly serious problem. In this project, a potentially scalable strategy to reduce the spread of misinformation is pursued: determine sets of nodes in a large network that, when blocked, would minimize the spread of fake news.

The foundation of our approach are Stackelberg Games. The specific Stackelberg Game for this project is as follows: the defender first chooses a number of nodes to block, after which the attacker chooses a number of nodes to attack that will maximize the spread. The defender does so by greedily choosing nodes, whereas the attacker tries to maximize their influence using Greedy and CELF algorithms.

Jack Kreuger, Concordia University (Undergraduate),
Getting to the Roots of Fractal Trees

In 1999, Michael Frame and Benoit Mandelbrot wrote a paper discussing self-contacting symmetric fractal trees. Given a certain branching angle, one can find the scaling ratio such that two branches converge to the same point, creating an inverted Koch curve by self-similarity. I then looked at asymmetric fractal trees, formed in one case by shifting one branch down the trunk, and in another case by choosing different left and right angles. These differences yielded unexpected results, from canopies constructed via an affine transformation to space filling dragon curves.

Blake Mattson, University of Minnesota–Duluth (Graduate)
Idempotents and Triempotents in Z_n and $Z_{n[i]}$

In this paper, I investigate the elements in Z_n, the integers modulo n, and the elements in $Z_{n[i]} = \{x + yi \mid x, y \in Z_n\}$ that have the property $a^2 = a$ (idempotents) or the property $a^3 = a$ (triempotents). Elements of the first kind are typically defined in abstract algebra textbooks. As far as I know, this paper is the first one to study elements with the property $a^3 = a$.

Lauren Mossman, St. Olaf College (Undergraduate),
Josey Sorenson, University of Minnesota,
Jose Alanis, Sacramento State University
Modeling Climate Change's Impact on Macrocystis pyrifera

There is growing concern that climate change may impact the geographical distribution of foundation marine species. Macrocystis pyrifera, also known as giant kelp, is one prime example. M. pyrifera provide a habitat for marine animals around the world. Reproduction, growth, and survival of giant kelp is known to depend on local temperature, irradiance, and pH. Giant kelp reproduce via alternation of generations, whereby an asexual sporophyte releases haploid spores that go on to form sexed gametophytes, the females of which yield juvenile sporophytes. Differing sensitivities to temperature and other abiotic conditions in these two phases may influence population responses to climate change. Therefore, we developed a mathematical model for giant kelp population dynamics along the California coast, which includes abiotic conditions and age-structured population dynamics. This model provided insights into how increasing sea surface temperature negatively affects M. pyrifera and predicts how future M. pyrifera populations will decrease as a result of the increasing global temperatures.

Jake Peters, Concordia College (Undergraduate)**,**
Alex Voigt, Concordia College
Modeling Housing Prices in the Fargo-Moorhead Area

It is vital to homebuyers, sellers, and realtors alike to be able to accurately appraise the value of a home. There are many applications and websites that model the sales price of houses across the entire United States; however, due to the broad scope of these models, they may not be able to fully capture the intricacies of local markets. This presentation examines real estate submarkets within the Fargo-Moorhead area using hierarchical linear modeling and hedonic valuation.

Travis Peters, College of St. Benedict/St. John's University,
James Schwinghamer, University of Minnesota—Duluth
Lights Out on the Hypercube Graph over the Ring of Integers Modulo k

We explore the Lights Out game played on the hypercube graph. The vertices of the graph can be thought of as buttons with different colors of lights, and the edges of the graph determine how neighboring vertices change color when a vertex is pressed. We use two rules, called open and closed neighborhood switching, to determine which vertices change color when a vertex is pressed. Using these two rules, we determine when every initial configuration of lights on the hypercube graph can be turned off.

James Sellers, University of Minnesota—Duluth
Sequentially Congruent Partitions and Partitions into Squares

Recently, Max and Robert Schneider studied a curious class of integer partitions called "sequentially congruent" partitions. After defining these partitions and sharing a number of results that Schneider and Schneider proved, we will prove an unexpected relationship between sequentially congruent partitions of weight n and partitions of weight n where all parts are squares. The talk will be self-contained and should be enjoyable for experts and non-experts alike! This is joint work with Robert Schneider and Ian Wagner.

Tom Sibley, St. John's University/College of St. Benedict (Retired)
Word Length in Groups

The generators of a group play an important role in group theory. Combinatorialists have investigated in depth the distribution of word length for groups where all the generators have order two. (Word length is the number of generators needed to build a given element.) My former student, Karen Phillips, and I investigated this idea for some families of groups with some generators not of order two. I will present some of our results.

Emma Spors, South Dakota State University (Graduate)**,**
Semhar Michael, South Dakota State University
Standardized Incidence Ratio of the COVID-19 Pandemic: A Case Study in a Midwestern State

COVID-19 has made a dramatic impact around the world, with some communities facing harsher outcomes than others. We sought to understand the impact of COVID-19 in counties from the rural state of South Dakota. The Standardized incidence ratios, using age-adjusted hospitalization and death rates, were computed to compare counties to expected outcomes based on a reference population. In addition, a penalized generalized linear regression model was used to identify factors that were associated with hospitalizations and deaths. The results identified counties that had different outcomes than expected. Race and education were selected as significant factors associated with the designated outcomes.

Chi Tran, Concordia College (Undergraduate)**,**
Kayla Selvig, Concordia College
The Hiring Problem: Modifications and Win Strategies

Our research focuses on optimal stopping problems in the context of the Secretary Problem, a scenario in which a fixed number of candidates, N, are interviewed one at a time and given a unique relative rank. There is a known optimal strategy for hiring the best candidate in the classical version of the problem. We are interested in finding strategies that will help us hire the best candidate in variations of the secretary problem. These include permutation pattern avoidance to avoid less-desirable scenarios, consecutive permutation pattern avoidance, and optimal strike set.

Aaron Wangberg, Winona State University
Transforming calculus discussions with Desmos ~ (and Colab and Github)

Desmos is a nice toy. But one feature, the Desmos ~, lets instructors change the way students generate calculus content, investigate theory, create models, and understand error tolerances. In this talk, I'll share how this simple tool can modernize and simplify computational approaches to Calculus instruction. Along the way, I'll show how Desmos, Colab, Google Sheets, and Github combine to provide a nice, friendly, usable environment for students.

Mike Weimerskirch, University of Minnesota
Flipping the Formula in Active Learning Classrooms

The University of Minnesota teaches PreCalculus courses in an active learning format, focusing on two main areas: computational literacy and communication skills. Students learn computation through video content and an automated homework system. The focus of in-person instruction is on problem-solving group activities that develop communication skills. The goal is to get students to view mathematics not as an arbitrary system of rules that lead to answers, but rather as a toolbox to make sense of interesting problems. Methods of evaluating students' ability to communicate will be discussed.

Marshall Whittlesey, California State University–San Marcos
Using Quaternions to Prove Theorems in Spherical Geometry

It is well known that the complex numbers can be used to do transformation geometry in the plane. In particular, a rotation by angle θ about the origin is accomplished via multiplication by the complex number $e^{i\theta} = \cos(\theta) + i\sin(\theta)$. It is less well known that the quaternion algebra (consisting of expressions of the form $a + bi + cj + dk$ with $i^2 = j^2 = k^2 = ijk = -1$) can be used to do similar transformations in three-dimensional space. We show how to use quaternions to prove a significant classical theorem in spherical geometry. These methods are featured in the speaker's new book with CRC Press *Spherical Geometry and its Applications*.

Yutong Wu, Macalester College (Undergraduate)**,**
Charles Zichen Zhang, Macalester College
Characterization of Rectifiable Measures that are Carried by Lipschitz Graphs

The Analysts' Traveling Salesman Problem asks for necessary and sufficient conditions under which a set is contained inside of a Lipchitz image. One direction for further study is to find a characterization of measures carried by Lipschitz graphs. In previous work, balls centered at each point in the support are used to give a characterization of doubling measures that are carried by Lipschitz graphs. To further extend that work, we develop and prove sufficient and necessary conditions for doubling measures carried by Lipschitz graphs in terms of dyadic cubes. Along the way, we prove a doubling measure property and a geometric lemma for measures that hold under the dyadic cube regime. These new results provide a characterization of measures carried by Lipschitz graphs that is more discrete in nature.

Jed Yang, Bethel University
Triangles, Rhombi, and Hexagons Can Count

By counting the number of tilings formed by triangular and rhombic puzzle pieces (introduced by Knutson, Tao, and Woodward), we can calculate Littlewood-Richardson coefficients, which are numbers that pop up in surprisingly different places all over various fields of mathematics. For example, these numbers are useful for multiplying Schur polynomials when dealing with symmetric functions or for studying the cohomology ring of Grassmannians in algebraic geometry.

We describe a new hexagonal puzzle piece, whose addition allows us to multiply dual stable Grothendieck polynomials or study the K-homology of Grassmannians.

No background in symmetric functions or algebraic geometry is assumed for this talk. Joint work with Pasha Pylyavskyy.

NCS MAA Spring 2022 Meeting Stay tuned for information!