Mathematical Association of America

North Central Section

Fall Meeting • September 22-23, 2023
University of Minnesota Duluth
Duluth, Minnesota

Friday, September 22, 2023 (6:00pm – 10:00pm)	
6:00 – 8:30	**Registration** Solon Campus Center Wedge $25/Free for Invited Speakers, Students, Retired, VITAL Faculty and HS Educators
6:30 – 7:00	**Welcome and Announcements** **Welcome by Wendy Reed, Dean, Swenson College of Science and Engineering** SCC 120 Jeremiah Bartz, MAA-NCS President
7:00 – 7:50	**Estimation Game** SCC 120 Led by: Rob Thompson, Carleton College MAA-NCS Student Activities Coordinator
8:00 – 9:00	**Sustainable Mathematics: A Community-Building Approach** SCC 120 Jeremiah Bartz, Presiding Melissa Hanzsek-Brill, NCS 2023 Teaching Awardee St. Cloud State University
9:00 – 10:00	**Reception** Solon Campus Center Wedge

Thank you to UM Duluth's faculty, staff and students involved in the effort of hosting this meeting.

Saturday, September 23, 2023 (7:30am – 4:25pm)

7:30 – 11:00	**Registration and Breakfast** Solon Campus Center Wedge	
7:40 – 8:20	**Business Meeting** SCC 120 Jeremiah Bartz, MAA-NCS President	
8:20 – 8:30	**Welcome by James Sellers, MAA NCS Officer and UM Duluth Professor** **University of Minnesota Duluth**	
8:30 – 9:20	**Graphs and Hypergraphs and Topology, Oh My!** SCC 120 Jeremiah Bartz, Presiding Emilie Purvine, MAA AWM Speaker Pacific Northwest National Laboratory	
	SCC 120	**SCC 021**
9:30 – 9:50	**The Matrix, Reinterpreted** Mathew Etterson, US EPA	**Complementing and Complimenting Klein** Tom Sibley, College of St. Benedict/St. John's University
9:55 – 10:15	**Atmospheric Kinematics** Dale Buske, St. Cloud State University	**65 Years of Art in Hyperbolic Geometry** Doug Dunham, University of Minnesota Duluth
10:20 – 10:40	**A Sample of Mathematics Used in Environmental Protection** Nathan Pollesch, US EPA	**Digging for Roots of Unity** Paul Zorn, St. Olaf College
10:45 – 11:05	**Calculus of Sustainability** Lori Ziegelmeier, Macalester College	**A Survey of Progress on Random Disjoint Placement of Shapes via Shier's Algorithm** Christopher Ennis, Normandale Community College Inge Helland, University of Oslo
11:05 – 11:15	**Break**	

Saturday, September 23, 2023 (7:30am – 4:25pm)

11:15 – 12:05	**A Surrogate-Based Strategy for Analyzing and Forecasting Geophysical Hazards** SCC 120 Jeremiah Bartz, Presiding Elaine Spiller Marquette University	
12:15 – 1:30	**Lunch**	
	SCC 120	**SCC 021**
1:30 – 1:50	**An Algorithmic Approach for Persistent Relative Homology Using Matrix Factorization** Xintan Xia, Macalester College Christian Lentz, Macalester College	**Math Meets the City** Jeremiah Bartz, University of North Dakota Ryan Zerr, University of North Dakota
1:55 – 2:15	**Some Lessons Learned Over Twenty Years as a Quant** Gary Hatfield, University of Minnesota - MCFAM	**The Bricklayer's Challenge** Barry Cipra
2:20 – 2:40	**Topological Data Analysis of Knowledge Networks** Adam Schroeder, Macalester College Jingyi Guan, Macalester College	**Unleashing the Potential of Calculus Students** Paul Herstedt, Macalester College
2:40 – 2:50	**Break**	
2:50 – 3:10	**Some Algebraic Techniques for Ramsey Theory** Bryce Christopherson, University of North Dakota	**Liberating Community College Math and How You Can Help** Ben Weng, Minneapolis College
3:15 – 3:35	**Four Polytope Products: Join, Fusil, Prism, and Meet** Tom Ruen	**Numberless Grading for One Thousand PreCalculus Students** Shelley Kandola, University of Minnesota Mike Weimerskirch, University of Minnesota
3:40 – 4:00	**Robust Kibria-Lukman Strategy for the Negative Binomial Regression with Applications** Adewale F. Lukman, University of North Dakota Rasha A. Farghali and Mohammad Arashi	**Communication Rubrics in Large Enrollment Classes** Mike Weimerskirch, University of Minnesota
4:05 – 4:25		**An Introduction to the Distributed Open Education Network (Doenet)** Duane Nykamp, University of Minnesota Twin Cities

Abstracts
Invited Addresses

Melissa Hanzsek-Brill, St. Cloud State University &
MAA-NCS 2023 Teaching Award Winner
Sustainable Mathematics: A Community Building Approach

Community-building mathematics represents a transformative approach to mathematics education that empowers learning communities and nurtures a generation of problem solvers through the whole learning life cycle. This talk will showcase examples of successful initiatives that embody the principles, benefits, and real-world applications of this approach, highlighting its potential to foster active engagement, inclusivity, and meaningful learning experiences within diverse communities with a focus on sustaining the importance of mathematics in the public eye.

Emilie Purvine, Pacific Northwest National Laboratory &
MAA AWM Speaker
Graphs and Hypergraphs and Topology, Oh My!

Mathematical structures and concepts can be great models of real-world data. For example, differential equations have a long history of success in applied mathematics to model dynamics found in rivers and oceans, the atmosphere, and molecular systems (just to name a few!). Network science is an area of applied math that uses graph structures to model relational systems like social, collaboration, and transportation networks. Graphs, however, are limited to modeling pairwise relationships among entities. Hypergraphs and topological spaces provide alternate models of relational systems that allow for arbitrary sized and structured relationships. In this talk I will introduce the mathematical concepts of graphs, hypergraphs, and topology and show how they are used to model real-world data from a variety of applications including biological systems, chemistry measurements, and cyber networks. We'll also talk about what measurements and properties of these structures can tell us about the systems they model.

Elaine Spiller, Marquette University
A Surrogate-based Strategy for Analyzing and Forecasting Geophysical Hazards

Geophysical natural hazards — storm surge, post-fire debris flows, volcanic flows, and ash fall, etc. — impact thousands to millions of people annually. Yet the most devastating hazards, those resulting in loss of life and property, are often both geographically and temporally localized. Thus, they are effectively rare events to those impacted.

We will present methodology to produce probabilistic hazard maps that can rapidly be updated to account for various aleatoric scenarios and epistemic uncertainties. This hazard analysis utilizes statistical emulators to combine computationally expensive simulations of the underlying geophysical processes with probabilistic descriptions of uncertain scenarios and model parameters. The end goal is not a map, but a family of maps that represent how a hazard threat evolves under different assumptions or different potential future scenarios. Further, this approach allows us to rapidly update hazard maps as new data or precursor information arrives.

Contributed Talks

Jeremiah Bartz, University of North Dakota, Ryan Zerr, University of North Dakota
Math Meets the City

This talk discusses experiences teaching a modeling course offered through the PIC Math program. In this course, students applied data science and modeling methods to analyze complex data sets related to questions of interest from the local city government.

Dale Buske, St. Cloud State University
Atmospheric Kinematics

Since 2019 the presenter has taught a unique course with this title supporting meteorology students at St. Cloud State University. This talk will discuss the purpose, development, content, and future of this course. Examples of the mathematics included, excluded, and emphasized may be insightful to current mathematics teachers.

Bryce Christopherson, University of North Dakota
Some Algebraic Techniques for Ramsey Theory

Ramsey theory addresses the mathematical phenomenon where the local structure of the objects in an ordered collection often becomes more regular beyond a certain bifurcation point, provided there is a suitable degree of global structure in the overall collection. Usually, a Ramsey-theoretic problem asks when this occurs, and the emergent local structure is constant in some sense (for instance, a monochromatic sub-graph). In this talk, we detail some algebraic tricks for characterizing classical Ramsey numbers and use this to show that there are interesting non-constant emergent local structures in ordered collections of objects with slightly different global structure requirements.

Barry Cipra
The Bricklayer's Challenge

A famous (albeit partly apocryphal) story has Gauss as a schoolboy speedily adding the numbers 1 to 100. When the speaker pondered how he might have approached the same assignment, he stumbled into an unsolved problem that might have tested Gauss himself.

Doug Dunham, University of Minnesota Duluth
65 Years of Art in Hyperbolic Geometry

About 65 years ago M.C. Escher was inspired to create his first patterns in the Poincaré circle model of hyperbolic geometry. About 20 years later students at UMD and I developed computer programs to re-create Escher's patterns and other related patterns. Later, starting in 2012 I applied Escher-inspired patterns to triply repeating polyhedra. I will discuss this progression and show samples of the resulting artwork.

Christopher Ennis, Normandale Community College, Inge Helland, University of Oslo (retired)
A Survey of Progress on Random Disjoint Placement of Shapes via Shier's Algorithm

Over the past decade the presenter and others have striven for a deeper understanding of Shier's algorithm, whereby an infinitude of successively smaller, seemingly arbitrary shapes can, under certain general conditions (areas decreasing according to a power law with negative exponent), be placed disjointly but otherwise randomly within a containing region of the same dimension, so as to completely fill the region (up to a set of measure zero). While sufficient geometric conditions have been established for a large class of 2-dimensional shapes to be so placed, necessary conditions remain largely unknown. We will review results achieved so far and discuss some recent work involving disjoint placement of intervals within the unit interval that may provide insight into the much more complicated 2-dimensional situation.

Mathew Etterson, US Environmental Protection Agency

The Matrix, Reinterpreted

Matrix models are used to study and manage age- and stage-structured populations. Analyses typically focus on eigenvalues and falsely assume a stable age- or stage-distribution. In Ecotoxicology, the value of population models is recognized, but they are rarely used. I propose an alternative interpretation of matrices and eigenanalysis as pertaining to an individual's lifecycle, rather than a population, in which analytical endpoints are individual fitness measures rather than population metrics. Under this perspective, the dependence of eigenvalues on their corresponding eigenvectors is a challenge, for which I propose a solution. I will illustrate with some examples of the utility and limitations of this novel interpretation for understanding the effects of environmental contaminants on bird populations. The views expressed in this abstract are those of the authors and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

Gary Hatfield, University of Minnesota – MCFAM

Some Lessons Learned over Twenty Years as a Quant

Nearly 25 years ago, I made the transition from academia to become a working actuary. Soon, I became engaged in financial mathematics (working as an actuary) and learned many things I never knew or understood as mathematics graduate student or a visiting assistant professor. In this talk, I will briefly summarize and share some of the key lessons learned.

Paul Herstedt, Macalester College

Unleashing the Potential of Calculus Students

What is the point of early undergraduate mathematics education? What are we really hoping our students get out of a course? My answer comes from my own personal experience in mathematics. After taking analysis, my writing ability drastically improved, my problem-solving ability drastically improved, and I was able to see deep connections between mathematics and other subjects. Do these outcomes need to wait until students are declared math majors in their senior year? Or can we help students obtain these skills from their first year in undergraduate mathematics? In this talk, I'll explain how one can take the lessons from "upper level" mathematics, make them approachable to first-year students, and obtain an affirmative answer to this question.

Shelley Kandola, University of Minnesota, Mike Weimerskirch, University of Minnesota

Numberless Grading for One Thousand PreCalculus Students

We give a preliminary report on the implementation of a numberless grading scheme used for 1140 students in precalculus courses at UMN-TC. These courses are delivered in-person in active learning classrooms, where each lead instructor is supported by a team of graduate and undergraduate teaching assistants. We will break down the support structure of the courses, the distribution of grading efforts, and students' responses to the grading scheme. This grading scheme was developed through conversations facilitated by the Minnesota Inquiry Teaching Network during a Summer 2023 reading of Clark and Talbert's "Grading for Growth."

Adewale F. Lukman, University of North Dakota, Rasha A. Farghali, Mohammad Arashi

Robust Kibria-Lukman Strategy for the Negative Binomial Regression with Application

Count regression models, particularly the negative binomial (NB) regression, are widely used in various fields, including biometrics, ecology, and insurance. Over-dispersion is commonly seen in dealing with count data, and NB regression has gained attention as an effective tool to address this challenge. However, multicollinearity among covariates and the presence of outliers can lead to inflated confidence intervals and inaccurate predictions in the model. This study proposes a comprehensive approach integrating robust and regularization techniques to handle the simultaneous impact of multicollinearity and outliers in the negative binomial regression. We investigate the estimators' performance through extensive simulation studies and provide analytical comparisons. The simulation results and the theoretical comparisons demonstrate the superiority of the proposed robust hybrid KL estimator (M-NBKLE) with predictive accuracy and stability when multicollinearity and outliers exist. We illustrate the application of our methodology to analyzing a forestry dataset. Our findings complement and reinforce the simulation and theoretical results.

Duane Nykamp, University of Minnesota Twin Cities

An Introduction to the Distributed Open Education Network (Doenet)

The Distributed Open Education Network (Doenet) is an open data-driven educational technology platform designed for creating interactive activities and measuring student interactions with those activities. Interactive activities are authored using DoenetML, a semantic markup language based on the PreTeXt XML vocabulary.

I will demonstrate how easy it is to author richly interactive content using DoenetML on our website doenet.org. I will also discuss the broader vision of Doenet and the PROSE Consortium, an open-source ecosystem that includes PreTeXt, Runestone, WeBWorK, and Doenet.

Nathan Pollesch, US Environmental Protection Agency, Office of Research and Development

A Sample of Mathematics Used in Environmental Protection

Challenges in environmental protection are extremely diverse with many opportunities to infuse environmental research with both new and established mathematical approaches. In this talk I will discuss three different active areas of environmental protection research and the mathematics that my research teams are using to approach them. I will give an overview of how ecological modeling is used for contaminant risk assessment, how aggregation theory informs bioenergy sustainability assessment, and how network analysis is applied to toxicological pathway discovery.

Tom Ruen

Four Polytope Products: Join, Fusil, Prism, and Meet

An n-polytope is defined recursively by $(n-1)$-polytope facets, 2 per ridge. 1-polytope: 2 points, segment body. 2-polytope: polygon with vertices and edges, 2 edges/vertex. 3-polytope: polyhedron, polygonal faces, 2 faces/edge. Polytopes can be characterized by f-vectors, like p-gon's f-vector: (p,p), p vertices and edges. Product polytopes like semiregular prisms and dual face-transitive bipyramids known since Kepler. Self-dual pyramids, skew polytopes also intriguing product forms. This talk presents 4 product operators: join, fusil, prism, meet $(\vee,+,\times,\wedge)$, computing f-vectors via vector products. E.g., cube's f-vector $(8,12,6,1)$ from prism triple product of segments $(2,1)$, coefficients from characteristic polynomial $(2+x)^3$.

Adam Schroeder (UG), Macalester College, Jingyi Guan (UG), Macalester College

Topological Data Analysis of Knowledge Networks

Knowledge networks can organize complex data by constructing graphs where nodes are concepts or ideas and edges represent connections of significance. Understanding the structure of these knowledge networks to uncover how science progresses over time is of interest to researchers studying the “Science of Science.” In this project, we are interested in understanding cycles or holes within a network, which can be thought of as gaps in knowledge. We use topological data analysis, and in particular, persistent homology filtered through time where the nodes represent scientific concepts and edges between two nodes are added at the time when they appear together in an abstract of a scientific paper. We study properties of these knowledge gaps in multiple dimensions such as when they form, when they no longer remain, and the concepts and papers that make up the cycles. We observe that papers involved in the knowledge gaps are cited more frequently than papers that are not.

Tom Sibley, St. John’s University and College of St. Benedict (retired)

Complementing and Complimenting Klein

In 1871 Felix Klein developed his model of the hyperbolic plane using the interior points of a circle. What is the geometry of the complement, the outside of the circle? As a compliment to Klein, we use a transformational approach (which he pioneered in 1872) to investigate this space, which mimics some aspects of hyperbolic geometry.

Mike Weimerskirch, University of Minnesota

Communication Rubrics in Large Enrollment Classes

PreCalculus classes at the University of Minnesota use activities on the Doenet platform to engage students in problem-solving. Students are expected to demonstrate communication skills in multiple ways and a graded using rubrics developed by elipss.com.

Ben Weng, Minneapolis College

Liberating Community College Math and How You Can Help

Two-year colleges serve over 40% of undergraduate in the US (CCRC, 2021). For a long time, its math education focuses only on developmental algebra and Calculus-related transfer courses, leaving non-STEM students underserved. As a result, most faculty prioritize numeracy (developmental algebra) and topic-to-topic transferability (transfer courses). I will analyze the situation based on my experience as an administrator and a participant of the State's math pathway reform. I will conclude the presentation with an open invitation to all (especially those at four-year institutions) to join force and liberate community college math from practices that stifle progress and innovation.

Xintan Xia (UG), Macalester College, Christian Lentz (UG), Macalester College

An Algorithmic Approach for Persistent Relative Homology Using Matrix Factorization Techniques

A central problem in data-driven scientific inquiry is how to interpret structures in large data sets uncovered by modern tools. The field of topological data analysis (TDA) provides a potential solution via persistent homology, which encodes features of interest as holes. A particularly important problem in TDA is to identify these topological holes in a dataset, as well as the original data generating them. We will discuss a matrix factorization technique to uncover these holes. We extend this technique to develop an algorithm for Persistent Relative Homology (PRH), which can identify features relative to some subset of the original data.

Lori Ziegelmeier, Macalester College

Calculus of Sustainability

What percentage of the US could be covered by solar panels to produce all of the electricity needs of the US? Under optimal conditions, how much power can a wind turbine of a certain radius produce? How can we determine how much water moves through a stream? These are some of the questions students explore in a Calculus of Sustainability course taught at Macalester College. In this talk, I will discuss the structure of this introductory course, which has a strong emphasis on developing scientific computing and mathematical modeling skills while focusing on sustainability applications.

Paul Zorn, St. Olaf College (retired)

Digging for Roots of Unity

Roots of unity are solutions of the equation $z^n = 1$ for positive integers n. There's not much to say for real z, but more of interest if we allow complex z. There are (exactly) n different complex nth roots of unity for every positive integer n; these roots have well-known but interesting and sometimes surprising algebraic, geometric, and (with help from Euler's formula) analytic properties. What's true, for instance, about sums and products of nth roots of unity? How do polynomials and trigonometric functions behave around such roots? I'll give examples and show some possibly striking pictures.