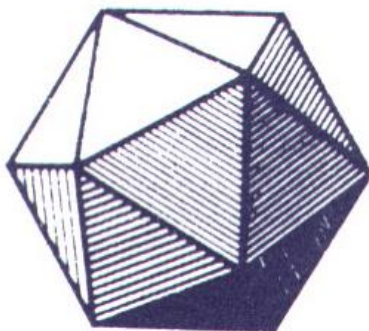


North Central Section

**Mathematical
Association of America**



Fall Meeting • October 12-13, 2018
Southwest Minnesota State University
Marshall, Minnesota

Friday, October 12, 2018

7:00 – 8:30 **Registration** – Lower Conference Center
\$15 (Free for Students and Invited Speakers)

7:00 – 8:00 **Book Display**, CH 225/226

Internet access: wireless access throughout campus

Invited Lecture – BA 102/202, Presiding: Matthew Zabka

8:00 – 8:50 **Michael Catanzaro, Iowa State University**
An Introduction to Topological Data Analysis

9:00 – 10:00 **Reception** – Lower Conference Center

9:00 – 10:00 **Undergraduate Poster Session** – Lower Conference Center

Book Discount Codes:

- **Members of the AMS or MAA get 40% off using the code: MT258MEM**
- **Non-Members get 25% off using the code: MT258NON**

Good through November 13th and Members receive free shipping!

Saturday, October 13, 2018

8:00 – 11:00 **Registration** – CH Link

8:00 – 11:00, 12:00-2:00 **Book Display** – CH 225/226

Undergraduate Session – CH 219, Presiding: Heather Moreland

8:30 – 8:50 **Nathaniel Sauerberg***, Grant Fickes, Dylan Green, Karen McCready,
Kathleen Ryan, Jill Stifano, Carleton College
Constructing a Family of Graphs with Maximum Proper Diameter

9:05 – 9:25 **Brook Stang**, Southwest Minnesota State University
Continuous Nowhere Differentiable Functions

9:30 – 9:50 **Rylee Sundermann***, Nicholas Stegmeier, Nathan McClanahan,
Jeffrey Doom, Jung-Han Kimm, South Dakota State University
A Study on Parallel Implementation of Biofilm

Morning Session II – CH 217, Presiding: Dan Kaiser

8:55 – 9:05 **Welcome:** Dean Amiee Shouse

9:05 – 9:55 **Section NExT Workshop**
Matthew Zabka, Southwest Minnesota State University
A Tutorial in Topological Data Analysis

Morning Concurrent Session I – CH 219, Presiding: Mu-wan Huang

10:05 – 10:55 **Section NExT Workshop**
Aaron Wangberg, Winona State University
Developing Mathematical Practice: Pulling Conjectures from Messy Situations

Morning Concurrent Session II – CH 206, Presiding: Matthew Zabka

10:05 – 10:25 **Alexander J. Barrios**, Carleton College
 $1 + 2 + 3 + \dots = -1/12?$ An Introduction to Analytic Continuation

10:30 – 10:50 **Shah Roshan Zamir** (graduate student), University of Minnesota-Duluth
Subgroups of Groups of Units Modulo n

Invited Lecture – CH 217, Presiding: Heather Moreland

11:00 – 11:50 **Barry Peratt**, Winona State University
Leveraging Applications and Cooperative Learning to Enhance Student Motivation and
Conceptual Understanding

12:00 – 1:00 **Luncheon** – IL 116

Student Activity

12:00 – 1:00 **Pizza and Math Quiz** – CH 219

Everyone can participate in this quiz game about mathematics, with questions ranging from math use in pop culture to undergraduate math courses.

1:05 – 1:40 **Business Meeting** – CH 217, Presiding: Sarah Jahn, Section President

Afternoon Concurrent Session I – CH 219, Presiding: Matthew Zabka

1:45 – 2:05 **Jennifer Galovich, College of St. Benedict/St. John's University,**
Jason Douma, University of Sioux Falls
Stretch Your Mind? There's a Σ for That!

2:10 – 2:30 **Anna Aboud*** (graduate student), **Heather Bolles, Elgin Johnston,**
Amanda Baker, Iowa State University
Two Studies on Team Based Learning

~~2:40 – 3:00 **Gary Hatfield, Securian Financial and University of Minnesota**
Why Yes, I *Do* Use Calculus in My Everyday Job!~~

3:05 – 3:25 **Megan Breit-Goodwin*, Ann Sitomer, Kathleen Quardokus Fisher,**
Jacqueline Dewar, Anoka-Ramsey Community College
Engaging Two-Year College Mathematics Faculty in SoTL

Afternoon Concurrent Session II – CH 206, Presiding: Dan Kaiser

1:45 – 2:05 **Mu-wan Huang, Southwest Minnesota State University**
Spirographs and Cyclic Subgroups

2:10 – 2:30 **David Radcliffe, Strength in Numbers Foundation**
A Product Rule for Triangular Numbers

2:40 – 3:00 **Roger W. Johnson, South Dakota School of Mines & Technology**
Playoff Series and the Incomplete Beta Function

3:05 – 3:25 **Jacob Duncan, Winona State University**
Mathematics for Sustainability

Afternoon Concurrent Session III – CH 204 Presiding: Wije Wijesiri

1:45 – 2:05 **Shelley Kandola** (graduate student), **University of Minnesota**
Digital Topology

2:10 – 2:30 **Shushuang Man, Southwest Minnesota State University**
Visualization and Comparison of Human and Chimpanzee Genomes by Using DNA
Walk and Wavelet Transformation

- 2:40 – 3:00 **Aaron Victorin-Vangerud*** (graduate student), **Bethany Kubik,**
University of Minnesota-Duluth
Nim in Topological Spaces
- 3:05 – 3:25 **Heather Moreland, Southwest Minnesota State University**
2D Simulations of a Pancreatic Islet Model Using Nonlinear Alternate Direction Implicit
Methods

Local Organizing Committee:

Matthew Zabka (chair), Mu-wan Huang, Dan Kaiser, Shushuang Man, Heather Moreland, Wije Wijesiri

Abstracts

Invited Addresses

Michael Catanzaro, Iowa State University,
An Introduction to Topological Data Analysis

Topological data analysis (TDA) is a relatively new area of data science motivated by algebraic topology. TDA provides a framework for studying the 'shape' of data in geometric and topological terms. In this talk, we'll discuss two of the main tools provided by TDA, persistent homology and mapper. We'll see how these tools can be applied through a variety of examples, as well as mention various software implementations. We assume no previous knowledge of algebraic topology.

Barry Peratt, Winona State University,
Leveraging Applications and Cooperative Learning to Enhance Student Motivation and
Conceptual Understanding

We will take a journey through a rather varied and eclectic set of mathematics problems used to structure cooperative learning activities. Along the way, we will explore the various learning opportunities that have arisen from these activities.

Matthew Zabka, Southwest Minnesota State University,
A Tutorial in Topological Data Analysis

We have seen (c.f. Catanzaro's talk) how the tools of topology can be applied to analyze data. In this workshop, we shall explore some of the software available in topological data analysis (TDA). We shall then discuss how undergraduates have used TDA in their research projects.

Workshop participants are encouraged to bring their laptop to work through exercises.

Section NExT Workshop

Aaron Wangberg, Winona State University,

Developing Mathematical Practice: Pulling Conjectures from Messy Situations

Mathematicians are really good at cleaning up messy problems, making vague statements precise, and proposing conjectures about underlying relationships. These practices, which align with the MAAs 2015 CUPM Guidelines for exploration and inquiry, can be practiced very early in (and throughout) the undergraduate curriculum. In this professional development workshop, we will practice doing mathematics as we turn messy situations into conjectures that help students discover fundamental calculus theorems.

This session is open to teachers and students.

Contributed Talks

Anna Aboud* (graduate student), **Heather Bolles, Elgin Johnston, Amanda Baker, Iowa State University,**

Two Studies on Team Based Learning

Team-Based Learning (TBL) is a specific form of active learning designed to collaboratively engage students in significant problem-solving tasks. By means of a flipped classroom, students are able to spend class time working in heterogeneous groups to apply fundamental concepts to an applied context. In recent years, the TBL structure has been applied to select Calculus sections at Iowa State University. Quantitative data has shown that the TBL students performed better on the midterm and final calculus exams, and gave higher quality explanations. In this talk we will explain how the TBL structure was implemented within the Calculus curriculum at Iowa State University, share samples of the rich mathematical tasks implemented, and present the results of quantitative and qualitative studies on the impact of this method.

Alexander J. Barrios, Carleton College,

$1 + 2 + 3 + \dots = -1/12$? An Introduction to Analytic Continuation

In 1851, Bernhard Riemann remarked that "if one extends [real] functions by allowing complex values for the argument, then there arises a harmony and regularity which without it would remain hidden." In this talk, we will give a glimpse of what Riemann had in mind by introducing the notion of analytic continuation. Analytic continuation is a powerful tool in modern mathematics. Roughly speaking, it allows the extension of the domain of some functions. Our focus will be on the Riemann zeta function $\zeta(s) = \sum_{n=1}^{\infty} \frac{1}{n^s}$ which will allow us to see via analytic continuation as to why some claim that $1 + 2 + 3 + \dots = -1/12$.

Megan Breit-Goodwin*, Ann Sitomer, Kathleen Quardokus Fisher, Jacqueline Dewar, Anoka-Ramsey Community College,

Engaging Two-Year College Mathematics Faculty in SoTL

Project SLOPE (NSF #1726891) is an exploration and design project that examines the opportunities and structures that support two-year college mathematics faculty engagement in the Scholarship of Teaching and Learning (SoTL). The organizational structures of associate degree granting institutions, the professional identities of two-year college mathematics faculty, and the distinctive contexts of teaching and learning in the first two years of college mathematics position this project in the frontiers of SoTL.

practice. This session will share the development of the AMATYC Project SLOPE Research Fellows Program and discuss the research that supports it.

Jacob Duncan, Winona State University,
Mathematics for Sustainability

Some of the biggest challenges facing humanity today stem from issues surrounding environmental degradation and social injustice, and the need to address the ramifications of these issues from a STEM perspective is greater than ever. This talk centers around the course Mathematics for Sustainability I recently developed and currently teach at Winona State University. The course develops and applies mathematical concepts and tools to quantitatively explore real-world, topical problems pertaining to environmental and social sustainability. Topics are motivated by exciting hands-on experiences – experiments, demonstrations, outdoor data collection excursions – from relevant STEM fields.

Jennifer Galovich, College of St. Benedict/St. John's University, Jason Douma, University of Sioux Falls,

Stretch Your Mind? There's a Σ for That!

The mathematician's nightmare: while you weren't looking your chair assigned you to teach an introductory course in

History of Mathematics or
Mathematics and Art or
Environmental Mathematics or...

and you know NOTHING about this topic! What to do? Contact your nearest SIGMAA!

This talk will introduce you to (remind you of?) the variety of Special Interest Groups of the MAA, highlighting the opportunities for making and deepening connections with colleagues who share your particular mathematical interests or pointing you to curriculum resources that will rescue you from your nightmare! Actual success stories will be provided.

Gary Hatfield, Securian Financial and University of Minnesota,
~~Why Yes, I *Do* Use Calculus in My Everyday Job!~~

~~Many undergraduates often hear that people who major in math often don't really use calculus on an everyday basis. They may hear this from others (including their professors) that this is true. This may be true for many careers, but it certainly *not* true for people pursuing a career in Quantitative Finance. I will give a couple example of how quants in fact use undergraduate level concepts from calculus, linear algebra, and numerical analysis on an everyday basis. I will then discuss the career of financial quant in a bit more detail and offer it as an important alternative (and lucrative) career path for undergraduate math majors to consider.~~

Mu-wan Huang, Southwest Minnesota State University,
Spirographs and Cyclic Subgroups

A spirograph is made by taking a circle around another circle. We will examine the number relations of a spirograph in modular arithmetic and show how drawing a spirograph sheds light on some theorems about cyclic groups as well as the ideas in the proofs.

Roger W. Johnson, South Dakota School of Mines & Technology,
Playoff Series and the Incomplete Beta Function

In a best of $2k + 1$ game playoff series your team wins individual games with probability p against an opponent. If game outcomes are independent, then it is straightforward to write the chance that your team wins the series as a sum involving binomial coefficients. Intuitive properties about this chance (e.g. that it should be increasing in p), generally difficult to verify using this sum, may be established once we rewrite this sum as an incomplete beta function.

Shelley Kandola (graduate student), University of Minnesota,
Digital Topology

Understanding the topology of digital images is a key first step in developing topological tools for image analysis and image processing algorithms. One way to compress an image is to partition it into regions whose interiors are one solid color, called Jordan curves. In 1990, Efim Khalimsky was the first to prove a digital Jordan curve theorem from a purely topological perspective. In this talk, I will go over the basics of finite topology, how to interpret a computer screen as a finite topological space, and what Khalimsky's digital Jordan curves look like.

Shushuang Man, Southwest Minnesota State University,
Visualization and Comparison of Human and Chimpanzee Genomes by Using DNA Walk and Wavelet Transformation

It was discovered that noncoding and intron containing DNA sequences induce long-range correlations that can be characterized by long-range stochastic dependence, but intron-less coding genes do not. In this paper, human and chimpanzee chromosomes are visualized as two-dimensional curves using DNA walk. The wavelet packet transformation is applied to denoise these 2D curves. Comparison shows that, with exception of the Y chromosomes, corresponding human and chimpanzee chromosomes have similar shapes.

Heather Moreland, Southwest Minnesota State University,
2D Simulations of a Pancreatic Islet Model Using Nonlinear Alternate Direction Implicit Methods

In response to an increase in blood glucose levels, insulin is released into the bloodstream by the pancreatic islets of Langerhans. As a result of this influx of glucose, the islets start bursting oscillations of the membrane potential and the intracellular calcium concentration. However, time delays of several seconds in the activity of distant cells in the islets have been observed, indicating that electrical and calcium wave propagation through the islets can occur. A robust biophysical model of a 2D pancreatic islet is considered. As the islets are roughly circular, polar coordinates will be employed. The resulting model equations contain two nonlinear reaction-diffusion equations. Using a modification of the standard Alternate Direction Implicit (ADI) Method proposed by Amiri & Hosseini for nonlinear parabolic partial differential equations, simulations are carried out of a pancreatic islet immersed in a glucose bath.

David Radcliffe, Strength in Numbers Foundation,
A Product Rule for Triangular Numbers

The triangular numbers satisfy the product rule

$$T(mn) = T(m)T(n) + T(m-1)T(n-1)$$

for all $m, n > 0$. Perhaps surprisingly, there are exactly five sequences that satisfy this equation.

I will explain how Python and Gröbner bases can be utilized to solve the more general equation

$$T(mn) = T(m)T(n) + T(m-1)T(n-1).$$

No previous background in Python or algebraic geometry will be assumed.

Nathaniel Sauerberg*, Grant Fickes, Dylan Green, Karen McCready, Kathleen Ryan, Jill Stifano,
Carleton College,

Constructing a Family of Graphs with Maximum Proper Diameter

In the study of edge-colored graphs, properly colored paths are those in which no consecutive edges have the same color. We use this notion to define proper distance and proper diameter, which is bounded by the length of the longest possible path in a graph. Looking specifically at when this upper bound is attainable in 2-connected graphs on 2 colors leads to the construction of the Tau graph family. We give intuitive justification that 2-connected graphs attain the maximum possible proper diameter if and only if they are Tau graphs and some observe other interesting properties of Tau graphs.

Brook Stang, Southwest Minnesota State University,
Continuous Nowhere Differentiable Functions

In 1806, A. M. Ampère published a paper in which he attempted to prove that a continuous function must be differentiable except on a set of isolated points. However, in 1872, Weierstrass constructed an example of a function that was continuous but differentiable at no point. In this presentation, we shall discuss the discovery of functions that are continuous but nowhere differentiable and present a different example of this kind of function.

Rylee Sundermann*, Nicholas Stegmeier, Nathan McClanahan, Jeffrey Doom, Jung-Han Kimn,
South Dakota State University,

A Study on Parallel Implementation of Biofilm

Biofilms are a group of microorganisms that adhere to each other and a surface. We used the Cahn-Hilliard equation because it models how fluids can mix and separate into pure states. Utilizing the data structures contained in PETSc (Portable Extensible Toolkit for Scientific Computing) which is developed at Argonne National Laboratory, we crafted a parallel implementation of the Cahn-Hilliard equation to model the biofilm. We will discuss the implementation of efficient parallel simulation procedures based on parallel numerical algorithms and toolkits including PETSc and future work.

Aaron Victorin-Vangerud* (graduate student), **Bethany Kubik, University of Minnesota-Duluth,**
Nim in Topological Spaces

Nim is a classic combinatorial game played on finite “piles of rocks” in which two players take turns selecting a pile and removing some of its rocks—the player removing the last rock is the winner. This talk presents preliminary work attempting to play Nim in topological spaces. With covering sets as rocks, partitioned into piles, players choose rocks until the accumulated collection forms a cover. In a special case involving finite covers, a measure is defined, making possible an analysis of winning strategy similar to that in Nim.

Shah Roshan Zamir (graduate student), **University of Minnesota-Duluth,**
Subgroups of Groups of Units Modulo n

The set of all positive integers less than n and relatively prime to n with multiplication mod n is a group denoted $U(n)$. These groups are useful in algebra, number theory and computer science. We are interested in subgroups of $U(n)$. As part of their 1980's paper titled *Factoring Groups of Integers modulo n* , Gallian and Rusin determined the structure of $U(n)$ and $U_s(n)$ for $n = st$ where $\gcd(s, t) = 1$ and $U_s(n) = \{x \in U(n) \mid x \pmod{s} = 1\}$. Inspired by their work and some exercises in Gallian's *Contemporary Abstract Algebra*, we identified new families of subgroups of $U(n)$. For a subgroup H of $U(n)$ and an integer k we define:

$$U_{k,H}(n) = \{x \in U(n) \mid x \pmod{k} \in H\}.$$

We give a complete classification of these subgroups and their factor groups for the special cases of $H = \{1\}$ and $H = \{1, -1\}$. We also define $U^{(k)}(n) = \{x \in U(n) \mid x^k = e\}$ and $U(n)^{(k)} = \{x^k \mid x \in U(n)\}$. Our results completely classify the latter subgroups and their factor groups.

Undergraduate Student Posters

Gregory Bowen*, **Dennis Agnew Jr, Nicholas Stegmeier, Fernando B. Dos Reis, Jung-Han Kimn, Timothy Hansen, Southwest Minnesota State University,**
A Study on Parallel Simulation for ACOPF (Alternating Current Optimal Power Flow) using the PETSc DMNetwork Object

Simulating Alternating Current Optimal Power Flow (ACOPF) is essential for reducing the cost of electricity. In order to solve the ACOPF problem, we modeled a linear Direct Current Optimal Power Flow (DCOPF) problem in the C package PETSc for parallel computation. Through the implementation of the abstract data structure DMNetwork and the nonlinear optimization solver TAO we preserved the structure of the network and its physics in a flexible, expandable, representative format while still maintaining access to the data within the network. The resulting simulation code is being adapted for future research into ACOPF with modifications.

Nathaniel Sauerberg*, Grant Fickes, Dylan Green, Karen McCready, Kathleen Ryan, Jill Stifano, Carleton College,

Constructing a Family of Graphs with Maximum Proper Diameter

In the study of edge-colored graphs, properly colored paths are those in which no consecutive edges have the same color. We use this notion to define proper distance and proper diameter, which is bounded by the length of the longest possible path in a graph. Looking specifically at when this upper bound is attainable in 2-connected graphs on 2 colors leads to the construction of the Tau graph family. We give intuitive justification that 2-connected graphs attain the maximum possible proper diameter if and only if they are Tau graphs and some observe other interesting properties of Tau graphs.

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NCS MAA Spring 2019 Meeting at Augsburg College, Minneapolis, MN