



Southwest Minnesota State University

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Sponsored by the Department of Mathematics & Computer Science

Questions or Comments:

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## Keynote speaker:



Dr. Frank Lynch  
Associate Professor of Applied Mathematics  
Department of Mathematics  
Eastern Washington University  
Cheney, Washington

Frank Lynch earned his PhD in 2010 from the University of Utah, where he worked under the mentorship of Dr. James Keener and the Utah Mathematical Biology group. As a member of the Mathematics Department at Eastern Washington University, his research interests lie in the mathematical modeling of biological processes. At EWU, he helps oversee the new MS in Applied Mathematics as the Director of Graduate Studies.

## Keynote address:

### **Deconstruction of Hydraulic Conductance -- Analysis of Convergence**

A plant's ability to survive in arid environments can be characterized by its tendency to conserve water, which can be quantified by a parameter called axial conductance. We show how hydraulic conductance, an experimental quantity, can be decomposed into radial and axial conductance. Mathematically, this modeling effort involves finding the solution of a strangely formulated boundary value problem. Interesting mathematical issues arise when we work to better model the shape of the plant, which ultimately requires a hybrid approach to find a numerical approximation of the solution to the boundary value problem. We discuss this convergence of this hybrid approach.

## About the Conference:

The Mathematics on the Northern Plains Undergraduate Conference was established in the spring of 1999 by assistant professor Zsuzsanna Szaniszló and Dr. Daniel Schaal at South Dakota State University with a grant from Exxon. Although that grant has expired, the conference has continued each year providing the opportunity for undergraduate mathematics majors in the greater southwest Minnesota region to present their research projects to their peers and network with other young mathematics professionals in the region. This conference has routinely drawn students from South Dakota, Minnesota, and Iowa to the regional hosting universities such as Augustana University (2017), University of Sioux Falls (2018), and SDSU (2019). The conference was cancelled in 2019 due to weather and in 2020 due to the COVID-19 pandemic. We are back virtually in 2021 and in-person in 2022!



## Program Schedule

Time	Event
9:45 – 10:00 am	Logging in, Coffee & Conversation  Zoom ID: 975 7527 9991 Passcode: MNP2021  <a href="https://minnstate.zoom.us/j/97575279991">https://minnstate.zoom.us/j/97575279991</a>
10:00 – 10:30 am	Welcome Remarks - Dr. Kumara Jayasuriya President of Southwest Minnesota State University
10:30 – 11:30 am	Keynote Address - Dr. Frank Lynch Associate Professor of Applied Mathematics Eastern Washington University
11:30 am – 12:30 pm	Lunch break
12:30 – 3:00 pm	Student presentations – Breakout Rooms (25 minutes each, with five-minute break)
3:00 pm	Closing Remarks



<b>Breakout Rooms</b>	<b>Newton Room</b> <b>Moderator:</b> Dr. Heather Moreland	<b>Leibniz Room</b> <b>Moderator:</b> Dr. Shawn Chiappetta
<b>12:30 – 1:00 pm</b>	<i>Association Between Socioeconomic Factors and Breast Cancer Mortality in a Rural State</i>  <b>Emma Spors</b> South Dakota State University	<i>PCA on Crime Data and the Connection to Social Components</i>  <b>Nina Groene</b> University of Sioux Falls
<b>1:00 – 1:30 pm</b>	<i>Using Mathematical Modeling to Discover Expected Value</i>  <b>Naomi Peterson</b> University of Sioux Falls	<i>How Simple Can a Space-Filling Curve Be?</i>  <b>Thong Vo Hien</b> St. Olaf College
<b>1:30 – 2:00 pm</b>	<i>A Mathematical Model of Chemical Kinetics</i>  <b>Cora Engels</b> Southwest Minnesota State University	<i>Finding the Keys to the Peano Curve</i>  <b>Khang Vo Huynh</b> St. Olaf College
<b>2:00 – 2:30 pm</b>	<i>Predicting Transition Probabilities in Discrete Stationary Random Walks with Computer Vision</i>  <b>Jack Bressett</b> Cornell College	<i>The Axioms of Topology</i>  <b>Rachel Engels</b> Southwest Minnesota State University
<b>2:30 – 3:00 pm</b>	<i>Analyzing Augsburg Football Recruits Through Data Analytics: A Statistics Approach</i>  <b>Josh Anderson</b> Augsburg University	<i>Frobenius Templates in Certain <math>2 \times 2</math> Matrix Rings</i>  <b>Yuki Takahashi</b> Grinnell College



Mathematics on the Northern Plains

### **Analyzing Augsburg Football Recruits through Data Analytics: A Statistics Approach**

Josh Anderson – Augsburg University

Breakout Room – Newton Room at 2:30 pm

In my research I collected data on Augsburg football recruits and analyzed them in a variety of ways. I focused my attention on looking at the recruits academic performance in high school and how it affected their ability to receive scholarships. I used my prior knowledge and expertise in statistics to work with this data in RStudio in order to understand and explain the results of the dataset. This project gives the Augsburg football coaching staff a better idea which GPA they need to look at for a recruit and how much they will receive in scholarships.

### **Predicting Transition Probabilities in Discrete Stationary Random Walks with Computer Vision**

Jack Bressett – Cornell College

Breakout Room – Newton Room at 2:00 pm

I simulated random walks on a grid, each determined by four transition probabilities, the probabilities of moving in each direction. I asked whether it was possible to recover the probabilities used to make the walk only by looking at an image of the walk's path. I created the ACE and PACE deep neural networks to compute the transition probabilities for a given image. ACE and PACE overcame memory access constraints and achieved exceptional prediction levels.

### **A Mathematical Model of Chemical Kinetics**

Cora Engels – Southwest Minnesota State University

Breakout Room – Newton Room at 1:30 pm

Chemical kinetics are of high importance in the field of physical chemistry as well as throughout all hard sciences, as they help us to understand the rates at which reactions proceed. The chemical kinetics of a system of reactions in quasi-equilibrium and quasi-steady-state approximations can be modeled mathematically incorporating linear algebra, vector spaces, and differential equations. The developed model is dependent on the experimentally determined rate constants for each individual reaction in the mechanism in addition to the concentrations of each reactant. In this project, we investigate the application of such methods using the reaction mechanism proposed for the oxidation of methane resulting in the formation of synthesis gas using a Co-ZSM-5 catalyst.



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### **The Axioms of Topology**

Rachel Engels – Southwest Minnesota State University

Breakout Room – Leibniz Room at 2:00 pm

Axioms are a set of statements in a logical system that are agreed upon without proof. The axioms then give a starting point from which we can deduce theorems in that system. Topology -- the study of continuity -- is given by three axioms. In this talk we shall consider how changes to topology's axioms affect the continuity of functions.

### **PCA on Crime Data and the Connection to Social Components**

Nina Groene – University of Sioux Falls

Breakout Room – Leibniz Room at 12:30 pm

Principal component Analysis (PCA) is a method of Dimensional Reduction while retaining as much information as possible. In this presentation, PCA was applied to Crime Data from Chicago to gain a better understanding of the Crime pattern. Crime Data has been analyzed in a way that allows to draw conclusion of what kind of crimes are connected to each other and in which community areas they occur. The next step is to perform a second PCA analysis on the crime and social data such as income, education, and life expectancy with the goal to find connections between them.

### **How Simple Can a Space-Filling Curve Be?**

Thong Vo Hien – St. Olaf College

Breakout Room – Leibniz Room at 1:00 pm

Throughout decades, space-filling curves on 2-dimensional space were studied dedicatedly by many famous mathematicians, which led to the discovery of many curves such as the Peano curve, Hilbert curve, and Lebesgue curve. Following that, many interesting properties and methods for categorizing these curves were also uncovered and proven. However, little work has been done for higher dimensions. This research will focus on constructing and analyzing 3-dimensional space-filling curves, as an attempt to build the foundation for constructing space-filling curves for higher dimensions later.



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### **Finding the Keys to the Peano Curve**

Khang Vo Huynh – St. Olaf College

Breakout Room – Leibniz Room at 1:30 pm

Many, but certainly not all, space filling curves are presented via a sequence of pictures or diagrams and this is certainly true of the Peano function, 1890. However, this is not the way Peano viewed things. Peano's proof was algebraic and any inherent geometry was opaque. Hilbert dissected Peano's proof with an eye to discover that inherent geometry, published it and simultaneously defined a “simplified” construction with new proof that was immediately referred to as the Hilbert curve, 1891. Here we present Hilbert’s geometry and use it to show the Peano Curve is at most 4-to-1 but never 3-to-1.

### **Using Mathematical Modeling to Discover Expected Value**

Naomi Peterson – University of Sioux Falls

Breakout Room – Newton Room at 1:00 pm

Mathematical modeling involves working with mathematics to explore and provide insight to real-world problems or phenomena. In this modeling project, students will discover expected value through creating a scavenger hunt game. They choose places or activities to do in their town and assign point values. They then must choose a time limit and a couple probable routes players could take. Using the point values and placement of locations, students will calculate different probabilities successfully completing all or part of reasonable routes. By comparing probabilities, they should be able to write and explain why a certain route will likely yield a high point total.

### **Association between Socioeconomic Factors and Breast Cancer Mortality in a Rural State**

Emma Spors – South Dakota State University

Breakout Room – Newton Room at 12:30 pm

In South Dakota (SD), breast cancer is the number one cancer diagnosed in women and the second leading cause of all cancer deaths. This study sought to understand how socioeconomic factors impacted breast cancer mortality rates at a county level in SD. The relationships were modeled using multiple linear regression with stepwise variable selection used to perform feature selection. We found a positive association between counties with lower percentages of high school graduates and increased breast cancer mortality rates which was consistent with the current literature. We also observed a negative relationship between poverty rates and breast cancer mortality which may need further study.



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### **Frobenius Templates in Certain $2 \times 2$ Matrix Rings**

Yuki Takahashi – Grinnell College

Breakout Room – Leibniz Room at 2:30 pm

The classical Frobenius problem is to find the largest integer that cannot be written as a linear combination of a given set of positive, co-prime integers using non-negative integer coefficients. Prior research has generalized this problem from the ring of integers to the ring of Gaussian integers and the rings  $Z\sqrt{m}$ . In this presentation, I will introduce a new generalization to the ring of  $2 \times 2$  triangular matrices with constant diagonal. I will present answers to two questions: for which lists of matrices is the Frobenius set non-empty, and what are the matrices in the Frobenius set? For the sets of two matrices, there is a construction of every matrix in the Frobenius set.