2019 SPRING PI MU EPSILON
SCHEDULE WITH ABSTRACTS

Friday, April 12

7:00pm.

PENGL 229 Trevor Brammer and Zachary Henderson (University of Wisconsin, River Falls)
Dragons and Mathematical Modeling : As participants on different teams, we approached the 2019 Mathematical Contest in Modeling Problem A: A Game of Ecology from two different perspectives. Our two teams independently came across some of the same allometric equations and used real-world data to formulate our models on dragon habitat. We will discuss the similarities and differences of our models, our experiences in the modeling competition, and our results that can be used to better understand both mythical and real animals in their respective environments.

PENGL 244 John Wallace (University of St. Thomas)
Analysis and Simulation of Knot Transitions : Knotting behavior pervades many scientific disciplines, from particle physics and fluid dynamics to biochemistry. Research has shown that knotted structures are a ubiquitous characteristic in some systems, and yet the scientific community does not yet have an explanation for the prevalence of these knots, nor what function they might serve. Some of these systems (DNA, for example) exhibit transitory behavior in which a knotted configuration transforms into a new configuration, possibly with different knotting characteristics. Our long-term research goal is to study these transition processes through computational simulation and analyze the transient knots. Doing so may provide insight into the environmental conditions that affect knotting behavior, and perhaps in the future will contribute to the scientific community's understanding of real-world knotted systems. Our recent work has focused on a simulation method based on Langevin dynamics, a mathematical model used in the study of dynamic molecular systems. We have applied this method to study transitions of tight knot configurations.

PENGL 248 Andy Hotchkiss, Brandon Perez (Augsburg University)
Curve Fitting of Periodically Repeating Functions : This investigation uses Earth observation data such as CO2 and Cumulative NEE and applies the concept of curve fitting of periodically repeating functions to them. Curve fitting is the process of finding a curve that best represents a dataset, and the periodic part of this means that the data repeat on a certain cycle. The concept of curve fitting can be used to predict data that are missing and forecast future data specifically. The data we worked with are CO2, GPP (Gross Primary Product), Cumulative NEE (Net amount of Carbon intake), and ET (Evapotranspiration). This investigation involved software to document, calculate, and graph necessary pieces for our conclusion. Based on what we found, we were able to use calculations such as the R2 and AIC values to determine how well a model worked with the data, and we plotted the curves of the fitted regressions using various software. We can conclude that the best fits for these data are helpful in predicting future values given that they are periodic, and if data were missing, we could use this procedure to estimate what the missing values are.

7:30pm.

PENGL 229 Jake Berran, Mitchell VonEschen, Jennifer Ai (University of Minnesota, Twin Cities)
Modeling Hierarchies : We created an agent-based model that simulates the movement of people in the workplace. Specifically, we consider the effects of homophily and bias on the upward progression of women through a professional hierarchy. The effect of homophily is present when people decide whether to apply for promotion, and bias influences the decision-making process of the hiring committee once the applicant pool

is determined. Using the model, we can see how these parameters affect the fluctuation of the distribution of women at each level of the hierarchy. This model was inspired by a paper co-authored by Dr. Hill, which analyzes a continuous model as a dynamical system.

PENGL 244 Matthew Colin Ward (University of St. Thomas)
Classifying Knots Using Neural Networks and Machine Learning : The goal of our project was to see if neural networks could classify knots. The simplest case for such an experiment was to use 6 edge equilateral knots, of which there are only three kinds of knots: the Unknot, the -Trefoil and the +Trefoil. The experiments we performed focused on determining the best way to present the knots to the neural network in order to maximize classification accuracy. The results from our experiments showed us that presenting the neural network with images of knots that have contrastingly colored edges and an orthographic projection increases knot classification accuracy. We also found that increasing the number of images of knots given to the neural network increases knot classification accuracy.

PENGL 248 Bardia Bijani Aval, Mitchell Hansen, Eddy MacDonald, Emily Twardy (College of St. Benedict and St. John's University)
A Determinant Game : We study a game played by two players on a square matrix. Each turn, a player enters a real number into one of the matrix elements. At the end of the game, the determinant of the matrix is computed. The player who goes first wins if the determinant is nonzero, and the second player wins otherwise. We discuss winning strategies for various square matrices.

8:00pm.
PENGL 229 Yuqing Wang (University of Minnesota, Twin Cities)
The Effect of Climate Change on the Resilience of Global Food Trade Network : With increasing globalization, the global trade of goods has dramatically increased, and food is no exception. The global food trade has exceeded 520 billion USD per year since 2013, and the global food network is becoming more complicated and interconnected as more countries become more dependent on each other. We choose beef as an example commodity for investigating the resilience of international food trade networks to weather- or climate-related disturbances. We find that the network of beef imports and exports follows a power-law distribution; has a relatively low clustering coefficient, small transitivity, and low density; and is becoming more unstable over years where data is available. In addition, the majority of countries increase their connectivity, though this is limited to their geographic neighborhood rather than far-distant countries. Based on this case, we develop a dynamical systems model to simulate an extreme weather event or disaster, focusing on regions that play significant roles in the overall network. We quantify effects on a broad scale and explore bounds for the resilience of the network to these events.

PENGL 244 Harrison Piehowski (University of Minnesota, Morris)
Finding Relaxed Coloring of Certain Classes of Hypergraphs : A hypergraph is a structure consisting of a set of points (or vertices) and a sub-collection of vertices (or hyperedges). Given a hypergraph, $H = (V, E)$, we may "color" the vertices with at least two colors such that every vertex in each hyperedge has either the same color or different colors. We would like to find the least number of colors, $N^*(H)$, necessary to color a hypergraph, H, with the additional constraint that $N^*(H)$ is at least two. This problem is defined as a "relaxed hypergraph coloring," and it has applications in scheduling problems where we need to find the best way to schedule a list of tasks in such a way that certain tasks may be completed simultaneously. To solve this problem for a hypergraph of any size is considered NP-hard, meaning there is currently no known time efficient algorithm to solve it and there probably will not be one. However, we can look at certain classes of hypergraphs on which this problem is tractable. We will present preliminary results on the values of $N^*(H)$ for certain classes of hypergraphs and we will discuss methods to find or bound $N^*(H)$ for any H based on previous research results from other hypergraph-coloring problems such as graph coloring and mixed hypergraph coloring.

PENGL 248 Neil Lindquist (College of St. Benedict and St. John's University)
Reducing Memory Access Latencies using Data Compression in Sparse, Iterative Linear Solvers : Solving large, sparse systems of linear equations plays a significant role in certain scientific computations, such as approximating the solutions to partial differential equations. However, solvers for these types of problems usually spend most of their time fetching data from main memory. In an effort to improve the performance of these solvers, this work explores using data compression to reduce the amount of data that needs to be fetched from main memory. A variety of compression methods were tried, with certain methods able to improve the performance of the test case.

Invited Speaker- Talk 1.

8:30pm - Pellegrene Auditorium. Dr. Talitha Washington (Howard University)
Hidden Figures: The Mathematics of Katherine Johnson: What's the mathematics that Katharine Johnson used to send John Glenn into orbit and bring him back safely? Who was the mathematician that created the mathematics in the "Hidden Figures" Hollywood movie? Come and uncover the equations created by Johnson during the Space Race, and how the mathematical consultant, Dr. Rudy Horne, created the mathematics for the movie.

Saturday, April 13

9:00am.
PENGL 229 Heather Krumwiede (Augsburg University)
Comparative Study of Mathematical Middle School Texts Across Cultures : The Third International Mathematics and Science Study (TIMSS) in 2015 indicated that middle school students in South Korea, Japan, China, and Singapore outperformed students in the United States in mathematics. Researchers, such as Ji-Won Son, Tad Watanabe, and Jane-Jane Lo, have studied reasons for underperformance in the United States, focusing on junior high textbooks. This research discusses how to supplement junior high mathematics textbooks to invoke higher level thinking and learning in students.

PENGL 244 Keith Sullivan (Concordia College, Moorhead)
Centered Polygonal Lacunary Functions : Lacunary functions based on centered polygonal numbers have interesting features which are distinct from general lacunary functions. These features include rotational symmetry of the modulus of the functions and a notion of polished level sets. Further, the centered polygonal lacunary functions give rise to organized families of infinite, bounded, cyclic sequences, called p-sequences. This talk will explore some of the interesting features of centered polygonal lacunary functions and present a systematic, ground-up construction scheme for obtaining the p-sequences.
(Note: This talk will be 50 miuntes)

PENGL 248 Tyler Baxter (Saint Cloud State University)
A Mathematical Analysis of Newton's Laws Photonic Drag, Dark Matter, and the Milky Way : Dark Matter has been a staple of modern cosmology and modern astrophysics for the last half a century, however, there appears to be no concrete agreement on what this substance is composed of. Even worse, no experiment has yet detected any such signature of matter. This project explores the possibility that perhaps dark matter is a manifestation of an incomplete mathematical analysis of the physics of Newton's Laws. The presence for a new term, a photonic drag force, is justified and included in $\vec{F} = \dot{\vec{p}}$ analysis for the Sun – Milky Way system. The results were entered into computational software and extrapolated into the future to determine the nature of the system.
(Note: This talk will be 50 miuntes)

9:30am.
PENGL 229 Lewis Istok (Augsburg University)
Spirographs for Fun and Pedagogy : What's the math that goes into a Spirograph? What started off as a simple research topic opened up a wide range of uses for this simple toy in teaching secondary mathematics. Spirographs can be used to visualize relatively prime integers, factoring, least common multiples and other topics in the middle grades. For high school mathematics, modeling a Spirograph can incorporate trigonometric functions, vectors and matrix transformations all in one project. This talk will discuss these possibilities and more, with a mathematical depth approachable by an undergrad and a mathematical whimsy appreciable by all.

PENGL 244 Keith Sullivan (continued from previous period)

PENGL 248 Tyler Baxter (continued from previous period)

10:00am.
PENGL 229 Trevor Brammer and Zachary Henderson (University of Wisconsin, River Falls)
How Many Unused Seats Will a Theater Have on Couples Night : In our problem, we analyzed the expected proportion of empty seats in one infinitely long row when the seats are only occupied by couples that pick their seats randomly. We used recursive equations, differential equations with Laplace transforms, and infinite series to determine that the proportion of empty seats approached the intriguing result of e^{-2}. While this result was previously known, we solved it without consulting any of the literature pertaining to it; as such, it served as a good way to expose us as undergraduates to the research process and collaborative work in our intended fields of study.

PENGL 244 Laura LeGare (Concordia College, Moorhead)
Geodesic Interpolation On Sierpinski Simplices : In Euclidean space, two sets may be interpolated along straight lines connecting all pairs of points in the two sets. In more general spaces, interpolation happens along geodesics – shortest paths parameterized at unit speed. We study interpolation on Sierpinski simplices, which generalize the well-known Sierpinski triangle. In addition to finding an upper bound on the number of geodesics, we show some interesting self-similarity properties of interpolant measures, and prove an analogue of the classical Brunn-Minkowski inequality for interpolant sets.

PENGL 248 Jacob Pawlowski (Minnesota State University, Moorhead)
Predictive Policing - Using Math to Predict and Prevent Crimes : Until recent years, many policing practices were responsive to crimes that have already happened; recently, there has been a shift toward proactive policing strategies. By analyzing the underlying patterns of crimes, we can use mathematic models to predict when and where crime will happen next and direct our police forces accordingly. In this talk, we will first give an overview of predictive policing, and the advantages and disadvantages of the implementation of this practice in local law enforcement agencies. We will then discuss the mathematical patterns, models, and algorithm used, the software that has been developed, and how it works. We will also cover some of the research done by Dr. Andrea Bertozzi, who initialized the mathematical model. Finally, we will discuss the success of the implementation of this idea across various cities and agencies.

Invited Speaker- Talk 2.

10:30am - Pellegrene Auditorium. Dr. Talitha Washington (Howard University)
Nonstandard Finite Difference Schemes for a Nonlinear World: Many real-world phenomena tend to be modeled via nonlinear models. In the late 1980's, Ronald Mickens of Clark Atlanta University introduced the concept of a nonstandard finite difference scheme (NSFD) as a methodology which would best approximate solutions to systems of nonlinear differential equations. This talk will show how to construct NSFD

schemes for various nonlinear models, including the models for the spread of a disease models and the models for the infamous Tacoma Narrows Bridge.