2018 SPRING PI MU EPSILON
SCHEDULE WITH ABSTRACTS

Friday, April 13

7:00pm.
PENGL 229 Lydia DeMorett (CSB/SJU)
Modeling Assortative Mating - Creating configurations of conflicting counterparts : Studies show that individuals display preferences when choosing a mate. Assortative mating models take into account the organisms' preferences versus a random mating model which, while computationally easier, is less realistic. This study uses Markov chains to create a flexible model to analyze long term effects of different types of assortative mating. Previous models considered strictly positive or strictly negative assortative mating. We investigate when positive and negative assortative mating are combined.

PENGL 244 Bob Laskowski (Augsburg College)
Characteristics of Vortex Filaments Modeled on a Cubic Lattice at Zero Statistical Temperature : The purpose of this research is to better understand the behavior of small, violent vortices within larger tornadic flows called suction vortices. They are thought to exist in all tornadoes but are short-lived and difficult to observe. When they dissipate, they transfer their high kinetic energy to the surrounding flow, adding to the overall energy of the tornado. We modeled these vortices at zero statistical temperature using self-avoiding walks on a cubic lattice. We computed the minimum energy values for the largest filaments possible, using our results and patterns observed to extrapolate to larger filaments.

PENGL 248 Richard Marsh (Concordia University St. Paul)
From Bits to Blockchains : Our fast-paced world requires increasing secure and verifiable digital communications. Keeping prying eyes from sensitive corporate and government secrets is no simple task. This talk is the combination of two projects: one in cryptography and another focusing on immutable distributed blockchain networks. Blockchain networks rely on cryptography, which in turn relies on core number theory concepts. The goal of working on both projects at the same time was to understand these networks not only from a software development standpoint, but also to develop a better understanding of the exciting mathematics that make this technology possible.

7:30pm.
PENGL 229 Emma Cobian, Austin Wilcox, Roman Alvarado (UW River Falls)
It's All Greek to Me - An Investigation of the Diffusion of Languages Based on Dynamic Influences : We worked on Problem B: How Many Languages? in the 2018 Mathematical Modeling Contest, requiring competitors to advise a multinational service company about trends of global languages and location options for new offices. We considered influences of migration, official languages, GDP, population dynamics, and technologies in our modeling process. We will describe how we solved these problems by using three different models: a gravity model, compartmental analysis differential equation model, and a matrix model.

PENGL 244 Madeleine Oswood (Augsburg College)
Using the Gini Coefficient to Quantify Ecosystem Responses to Environmental Changes : Global climate change is one of the biggest problems the world is facing right now. It has become increasingly important to have a good understanding of this issue, and many different fields are coming together to try and find

solutions. Mathematics can be used to look for trends in environmental data using techniques such as statistics and calculus. In this talk, I will describe how I look for similarities and trends between different environmental data sets that have been gathered from 212 sites around the world, such as air temperature, precipitation, sunlight, and the carbon uptake period. I do this by using numerical integration to calculate the Gini Coefficient for the different variables, although it is normally used in an economic setting to measure resource inequality.

PENGL 248 Jimmy Hickey (Winona State University)
Data Science for Social Welfare : With the ever-increasing popularity of the Internet comes a deluge of publicly available data useful for providing insights on methods to better society. Data science involves the process of gathering, managing, analyzing , and communicating data. This presentation will explore each of these steps using mental health, medical, and police calls data. The ultimate goal of this process is to learn from the data and make implementable suggestions to improve society.

8:00pm.
PENGL 229 Jake Kirsch (CSB/SJU)
Lebesgue Integration : This will be a presentation on the main topic of Math 344, my Independent Study with Bret Benesh, Lebesgue Integration. It will go over Riemann Integration, show the faults, and show how Lebesgue Integration solves that problem.

PENGL 244 Ryan Masui (Augsburg College)
Exploring Particle Swarm Optimization Methods : Particle Swarm Optimization (PSO) is a population-based stochastic approach for solving continuous and discrete optimization problems. Beyond numerical optimization, PSO is a very flexible and robust algorithm, that can be adapted for other scientific applications such as genetic coding and modeling of swarm behavior. For this presentation we will introduce the original PSO algorithm, exploring its capabilities and applications, and then evaluate some of its limitations in efficiency, accuracy, and run time when optimizing complex surfaces. Next, we also test a variety of versions of the PSO algorithm, changing certain parameters related to the behavior of the swarm and observing any significant change in efficiency, accuracy, and run time. Future work will explore how PSO can be used in parameter estimations of data for a given sample size that can be applied to a larger population and in neural networks as a potential new and more efficient technique for coding artificial intelligence that can make decisions and suggestions based on a person's interests, needs, and wants.

PENGL 248 Gabriel Mancino-Ball (Winona State University)
An Exploration of the Z-Transform : This presentation will explore the theory of the Z-Transform and its applications in different areas of mathematics. Attendants will investigate an application of the Z-Transform in signal processing and learn how equalizers are used in music. Also, mathematical ideas will be discussed that use asymptotic analysis of divergent series to approximate functions.

Invited Speaker- Talk 1.

8:30pm - Pellegrene Auditorium. Dr. Tim Chartier (Davidson College)
Putting a Spring in Yoda's Step : When the character Yoda first appeared on the silver screen, his movements were due to the efforts of famed muppeteer Frank Oz. In Star Wars Episode II: Attack of the Clones, Yoda returned to the movies but this time the character was not a puppet but a digital image within a computer. This talk will discuss the role, or more aptly the force, of mathematics behind a few aspects of movie special effects. Armed with differential equations, animators can create a believable flow to Yoda's robe or a convincing digital stunt person.

Saturday, April 14

9:00am.

PENGL 229 Spencer Morrison (UW River Falls)

Removing Phosphorus from the Great Lakes Using Compartmental Analysis : We will use compartmental analysis to find the amount of time it takes to remove phosphorus from the Great Lakes. Phosphorus is a major contributor to Eutrophication, which is when bodies of water are taken over by algae and eventually leads to the disappearance of the lakes.

We find how long it will take to remove 90 percent of the phosphorus from Lake Erie, which is the most polluted of the Great Lakes, through the use of an Alum treatment. The method we use is compartmental analysis, which is a common method for solving first-order linear differential equations. We solve the resulting model using Geogebra and Mathematica.

PENGL 244 Brandon Tran (University of St Thomas)

The Search for All Composite Links : The Olympic Rings and the Borromean Rings are examples of mathematical links. Mathematicians have classified the so-called "prime links" through 11 crossings. The non-prime links, known as composite links, have not received as much attention as prime links. Due to applications in the sciences, e.g. the study of linking in proteins, there is an increasing need to be able to classify linking, both prime and composite, in physical systems. The goal of this project is to create a set of software tools to classify all links through 10 crossings. One subgoal is to have a classification for all composite links. We present the progress made towards this subgoal.

PENGL 248 Nicholas Meyer (Winona State University)

A Study of the Invariance of Finite-Dimensional Measures under Group Actions : Measure Theory gives a concrete way to discuss "sizes" of sets in a way that is compatible with the Riemann integral. Group Theory, on the other hand, provides a framework to investigate compositions of transformations. Using Representation Theory as a link between the two, one can study how "sizes" of sets change under transformations. Specifically, we examine the role of the classical matrix groups as invariant transformation groups for the Lebesgue measure on finite-dimensional, real measure spaces. We also examine the roles of subgroups to invariance, and work towards finding a generic condition that guarantee supergroup invariance.

9:30am.

PENGL 229 Stefan Nelson (MSU Moorhead)

Positivity and Slope Limiters for Lax-Wendroff Discontinuous Galerkin Methods : Hyperbolic conservation laws model phenomena characterized by waves propagating at finite speeds. A feature of such equations is that smooth initial data can become discontinuous in finite time – such discontinuities are referred to as shock waves. In recent years, the discontinuous Galerkin (DG) method has become one of the standard approaches for obtaining numerical solutions to hyperbolic conservation laws. For sufficiently smooth solutions, DG methods can be made arbitrarily high-order. However, when the solution becomes discontinuous (i.e., shock waves), DG methods can produce unphysical oscillations that result in large errors, numerical instabilities, and unphysical states such as negative densities. In this work my REU group studied the so-called Lax-Wendroff variant of DG. We formulate the method as a locally-implicit predictor step followed by an explicit corrector step. We develop a novel limiting strategy that works on both these steps and suppresses unphysical oscillations and maintains the positivity of key physical quantities. The resulting method is implemented in a Python code that we are making freely available and applied to several standard one-dimensional test problems.

PENGL 244 Zachary Sorenson (University of St Thomas)

Applying neural networks to identify knot types : Machine learning and neural networks are currently major buzzwords in technology. Amongst the long list of applications, these algorithms are useful for image processing, e.g. to differentiate between pictures of different types of animals.

Meanwhile, the overarching problem in knot theory is to classify the knot type of a given configuration. Humans tend to do a poor job at identifying these knot types visually. Can neural networks do any better? We analyze the simple case of six-edge equilateral knots, in which case only three different knot types are possible: unknot, positive trefoil, and negative trefoil.

PENGL 248 Michael Holmblad (Winona State University)
Chaotic Random Number Generation : This presentation focuses on creating and testing a pseudo random number generator (pRNG). We create a generator where the algorithm is based off of a chaotic dynamical system called the tent map. This paper goes through the process of how we modify the tent map so that it can be a viable pRNG. There has been research on the tent map as a generator, but not in this kind of sense. Since the tent map doesn't work that well on a computer, we tackle that problem. We then modify it so that we can get a much more random distribution. We then discuss the methodology for coding the generator, and then testing it. Then we determine whether the generator is worth using or not.

10:00am.
PENGL 229 Jacob Pawlowski (MSU Moorhead)
Predictive Policing: Using Math to Predict and Prevent Crimes : Up 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.

PENGL 244 Belinda Huang (University of St Thomas)
Analyzing knot transitions : Knots and entanglement are a part of nature. For example, there are knotted proteins, as well as enzymes that manipulate knotting in DNA during replication. Knots in nature can transform via physical processes to other types of knots. The goal of this project is to analyze changes in knotting arising from a certain dynamic process. Using software by Henri Orland and Cristian Micheletti (based on overdamped Langevin dynamics), we are able to transform any knot configuration to any other knot configuration. We use that software to analyze how different knots can decay to a circular configuration.

PENGL 248 Lewis Istok (Augsburg College)
Modeling Velocity Fields around a Vortex Breakdown in Tornadic Flow : In 1986, a KARE 11 news chopper recorded remarkably clear footage of a tornado over the Twin Cities suburbs of Fridley and Brooklyn Park. Based on this video, Pauley & Snow (1989) conjectured the presence of a vortex breakdown in the tornado. Based on the structural similarity between this conjectured flow and a family of flows corresponding to an axisymmetric, incompressible blob of vorticity (Moffatt, 1968), we explore some possible models of the velocity and vorticity fields around a tornadic vortex breakdown. Although these current models are incomplete, the generated flows offer some promising possibilities for future models and a better understanding of tornadic behavior.

Invited Speaker- Talk 2.

10:30am - Pellegrene Auditorium. Dr. Tim Chartier (Davidson College)
March MATHness : Every March, there is a lot of madness around "Who's number one?" The Division 1 NCAA men's basketball tournament, often called March Madness, begins! Millions of brackets are created in an attempt to predict the outcomes of the tournament. Who will win round by round? In this talk, we

will see how research in ranking algorithms created brackets for March Madness that beat over 90% of over 8 million brackets submitted to ESPN's online tournament. Have a sport you'd like to analyze? By the end, you'll know how to create your own ranking method to answer "Who's number one?"