# 2019 PME Conference Schedule

## 9:00–10:00: Registration & Breakfast - Williamson 3422/3423

## 10:00–10:15: Welcome & Introduction - Williamson 3422/3423

President Tressel, Youngstown State University
Dr. Wim Steelant, Dean, College of STEM
Alanis Chew, YSU PME Chapter President

| | Williamson 2201 | Williamson 2202 | Williamson 2203 | Williamson 2204 |
|---|---|---|---|---|
| 10:20-10:35 | Simon Richard | Erin Kolke and Sarah Vale | David Gessler James Lagese and Derek Miller | COMAP-MCM B Zhihan Li |
| 10:40-10:55 | Alex Schroeder | Maddie Cope | Colleen Dougherty | COMAP-MCM B Bishal Lamichhane Bikash Thapa and Pradip Rimal |
| 11:00-11:15 | Brady Tanguay | Olivia Bindas and Maddie Cope | Matthew Bush | COMAP MCM B Paul Tomosky, Vincent Thompson, and Dafni Pratt |
| 11:20-11:35 | Lauren Blasinsky | Lindsey Chludzinski | Logan Bell | COMAP MCM E Gyaneshwar Agrahari Luke Hetzel and Subham Singh |
| 11:40-11:55 | Brandon Eschborn | Shannon Miller | Kaila DeChristofaro and Jessica Lefler | COMAP MCM A Dipesh Bhandari Yogesh Sapkota, and Prinshep Yadav |

## 11:55–12:50: Lunch - St. John's Episcopal Church Hall

| | Williamson 2201 | Williamson 2202 | Williamson 2203 | Williamson 2204 |
|---|---|---|---|---|
| 12:50-1:05 | Payton Kuhns | Dylan Langharst | Christopher Woolfork | Gyaneshwar Agrahari |
| 1:10-1:25 | Mike Dahmen | Samuel Hockenberry | Ankur Basu | Bryson Stemock |
| 1:30-1:45 | Nathaniel Melnik | Patrick Cone | Taylor Sutton and Jeremy Sidoti | Linyuan Yu |
| 1:50-2:05 | Max Fisher | David Berdik | Josie Sabatino | Lulu Liu |

## 2:10: Closing Remarks - Williamson 3422/3423

Youngstown State has partnered with AT&T to deliver visitor wireless Internet access on campus through the "attwifi" wireless network. This is an unsecure wireless network and is not protected by any of the University's cyber-related safeguards. The code for access is: WP29-iQRZ-36. The AT&T wireless network is supported directly by AT&T.

# Morning Session 10:20-10:35

**10:20-10:35** **Simon Richard** **Williamson 2201**

**Finding the Height of a Tetrahedron (and beyond)**

iSTEM Geauga ECHS

Advised by: Ms. Moriah Wright

This presentation will explore how the height of regular $k$-simplicies change as dimensions are added and removed. Regular $k$-simplicies include regular lines, triangles, and tetrahedrons. We'll start with a problem from the 2016 YSU MathFest Challenge of Champions Test concerning the height of a tetrahedron, and then generalize for all $k$-simplicies.

**10:20-10:35** **Erin Kolke and Sarah Vale** **Williamson 2202**

**Insurance Contracts**

Kent State University

Advised by: Dr. Darci Kracht

As actuarial mathematics students, we often consider different types of insurance in a mathematical setting. However, for this presentation, we studied insurance in a more general setting to understand why an individual would purchase specific types of contracts. Everyone will need insurance at some point, so why not be prepared and learn which policy is best for you!

**10:20-10:35** **David Gessler, James Lagese, and Derek Miller** **Williamson 2203**

**Baby Boomer Generation**

Youngstown State University

Advised by: Dr. Moon Nguyen

The Baby Boomer Generation is the group of people who were born between the years 1946 and 1964 in the U.S. They make up a lot of the work force and play a big role in today's U.S. economy. When the Baby Boomer generation no longer exists, what will that leave for the other generations? We randomly collected 1200 deceased citizens from four different regions in the United States: Midwest, Northeast, South, and West. We were then able to organize our data into four different generations and proceeded to analyze our data. Finally, after applying a statistical analysis, we were able to predict the year that Baby Boomers die out.

**10:20-10:35** **Zhihan Li** **Williamson 2204**

**Idea on Annealing Simulation**

Youngstown State University

Advised by: Dr. George Yates

We discuss different kinds of linear programming methods, including the analytical hierarchy process and annealing simulation algorithm. We evaluate how these methods apply in 2019 COMAP Problem B.

# Morning Session 10:40-10:55

**10:40-10:55** **Alex Schroeder** **Williamson 2201**

**Parenthesis Combinations**

iSTEM Geauga ECHS

Advised by: Ms. Moriah Wright

Given an expression with $n$ terms, how many different ways can you group the terms using only parenthesis? This talk explores this question and how it relates to the innate nature of possible combinations using grouping symbols. It focuses on the beginning of an explicit formula that can generate the number of parenthesis combinations for $n$ terms and the variety of methods and processes that went into its creation.

**10:40-10:55** **Maddie Cope** **Williamson 2202**

**Light up the Darkness: An Application of Graph Theory to Merlin's Game**

Youngstown State University

Advised by: Dr. Alexis Byers

The Lights Out Game is a handheld electronic toy that was created in 1995. The goal of the game is to turn all the lights out on any given five by five game board. A variation of Lights Out game is Merlin's game, which is just like lights out except the center light should remain on. This talk will focus on applying Merlin's game to complete graphs, cycles, paths and wheels.

**10:40-10:55** **Colleen Dougherty** **Williamson 2203**

**Ancient Egyptian Multiplication**

Slippery Rock University

Advised by: Dr. Lyn Miller

The Ancient Egyptians seemed to be ahead of their time with their impressive contributions to mathematics. For this talk, I share the algorithm the Ancient Egyptians used for multiplying fractions and whole numbers. Understanding and perfecting the algorithm for whole numbers is half the battle, as Ancient Egyptian fractions provide a new level of complexity to the problem.

**10:40-10:55** **Bishal Lamichhane, Bikash Thapa, and Pradip Rimal** **Williamson 2204**

**Drones for Disaster**

Youngstown State University

Advised by: Dr. Paddy Taylor

Our main goal is to build a drone fleet which can deliver medical packages and preform video reconnaissance in the disaster affected areas. We have used a packing algorithm to find the best possible arrangement of medical packages inside a cargo bay which is to be delivered to different locations. To find the best locations to drop off the relief systems we have computed the coordinates using the concept of centroid.

# Morning Session 11:00-11:15

**11:00-11:15** **Brady Tanguay** **Williamson 2201**

**The Application of Game Theory to Football**

Siena Heights University

Advised by: Dr. Andrew-David Bjork

Although football can be a complex game with many variables, offenses have two broad strategies of passing or running the ball, while defenses can defend the run or defend the pass. Game theory uses the strategies of two "players" to determine an optimal strategy for the best outcome. According to the National Football League (NFL), run plays tend to gain less yards than pass plays do. So why don't offenses pass more? A defense knows this, so they can prepare to defend the pass. If a defense knows this, maybe the offense should run the ball more. But the defense knows that the offense knows this. The cycle goes on and on. Game theory allows these decisions to be quantified into expected returns to determine the most optimal strategy for teams. In this talk, we will discuss the specific optimal strategies for each team in the NFL playoffs over the last few years. Furthermore, we will look at each team's deviations from their optimal strategies and determine its effect on the outcome of games.

**11:00-11:15** **Olivia Bindas and Maddie Cope** **Williamson 2202**

**Let's Recommend a Deal! A Study of Recommender Systems in Python**

Youngstown State University

Advised by: Dr. Lucy Kerns

A recommender system is a machine learning technique that is widely used by almost every big company, especially in the e-commerce area; it is deployed by companies to recommend items to their users according to users' preferences, interest, or observed behavior about items. In general, a recommender system serves the purposes of presenting a ranked list of objects given input object and providing customers information to help them find relevant items. Recommender systems can be used in a wide variety of disciplines, ranging from astrophysics to zoology. The goal of our research project was to build and evaluate different recommendation algorithms based on association rules and dimensionality reduction. Although recommender systems have gained increasing popularity and widespread success for many deal sites there has been very limited research reported on recommendation algorithms dedicated specifically to the deal sites industry, with only a few known literature on deals recommendation algorithms. This talk will focus on recommender systems, specifically the one we will be coding.

**11:00-11:15** **Matthew Bush** **Williamson 2203**

**Is a Split Gender Model Useful in Modeling Zika?**

Youngstown State University

Advised by: Dr. Alicia Prieto

Mathematical modeling has, for a long time, played an important role in predicting and identifying potential epidemiological outbreaks. Due to recent world wide outbreaks, Zika virus is one vector borne disease garnering a lot of attention. Recent models of Zika have taken into account things such as sexual transmission and even symptomatic versus non-symptomatic transmission. With our model we seek to explore whether it is necessary to split the model not only by symptomatic and non-symptomatic, but also by gender. The goal of this model is to find the basic reproductive number individually in each gender and together to determine whether a split gender model is necessary in modeling Zika.

# Morning Session 11:00-11:15 (continued)

**11:00-11:15** **Paul Tomosky, Vincent Thompson, and Dafni Pratt** **Williamson 2204**

**Solution to COMAP 2019 MCM Problem B:**

**"Send in the Drones: Developing an Aerial Disaster Relief Response System"**

Indiana University of Pennsylvania
Advised by: Dr. John Chrispell

In 2017 the island of Puerto Rico was struck by Hurricane Maria causing extensive damage. Our problem was to investigate the use of drones to provide medical aid and video reconnaissance to relieve the situation. Based on the specs of the medicine packages, drones, and containers, we were able to decide the most optimal packing using the Less Flexibility Principle and chose drone B to carry these deliveries. We will show how we developed Python code to optimize the drop location for the ISO cargo containers. The locations provide a maximum distance from the drop location to the hospital delivery sites within the drone flight radius. We will also show how we modeled our drones flight pattern and calculated its flight ceiling of 200m. Finally, we will show how our model, if implemented, would provide an optimal surveillance pattern to over 50% of Puerto Rico. Initial surveillance could be effectively completed in 10 days and medical supplies included could supply the 5 hospital locations for about 30 days.

# Morning Session 11:20-11:35

**11:20-11:35** **Lauren Blasinsky** **Williamson 2201**

**The Dynamics of Traffic Formation**

Cleveland State University

Advised by: Dr. Shawn Ryan

Have you ever been waiting in traffic and wondered who caused it and how it formed? There are many different scenarios and variables that can help explain traffic formation. The main focus throughout my study was to see what a change in variance and speed limit due to outside factors could do to affect traffic flow. In order to test these variables, we built a first order microscopic model. The results to these variable manipulations will make you think the next time you are sitting in traffic.

**11:20-11:35** **Lindsey Chludzinski** **Williamson 2202**

**When Microscopes and Math Meet: Agent Based Modeling of Subcutaneous Infections**

Youngstown State University

Advised by: Dr. Alicia Prieto

The human body constantly encounters potential infectious agents. As such, the immune system is intricately orchestrated with several layers of defense and countless cells circulating throughout the body. Although a lot is known about the general processes involved in responding to invading pathogens, the field of immunology is constantly changing and the factors that determine how a given infection will behave are extensive. Using MATLAB, we are in the process of designing a cellular automata model of a basic subcutaneous infection. In time, we plan to develop a realistic, adaptable visual simulation of the innate immune response to infectious pathogens that can integrate mathematical equations and experimentally measured biological data. The final program would be utilized as both an educational tool and research device capable of being adjusted for new discoveries. This presentation will give an overview of the steps involved in the inflammatory response and phagocytosis of pathogens, detail how we are seeking to model this, and share how the use of mathematics can enable researchers to better understand our own natural mechanisms.

**11:20-11:35** **Logan Bell** **Williamson 2203**

**Roulette (Rolling) Curves**

Lake Erie College

Advised by: Dr. Tabrina Smith

The cycloid is one of the most famous curves in mathematics. It is generated by rolling a circle along a line and tracing the path of a point on the circle's circumference. But what happens if we instead roll a circle along the outside of another circle, or a parabola along a parabola, or a logarithmic spiral along a line? These are all examples of roulette curves, curves generated by tracing a point $P$ which is attached to a curve $R$ that rolls along a fixed curve $F$ without slipping. Each of these examples can be described–with some interesting results–and in fact a general formula can be derived.

**11:20-11:35** **Gyaneshwar Agrahari, Luke Hetzel, and Subham Singh** **Williamson 2204**

**COMAP: Problem E**

Youngstown State University

Advised by: Dr. George Yates

The environmental cost of projects using four different factors including cost of land lost, environmental services, factory pollution and land replacement are presented as part of the COMAP modeling contest.

# Morning Session 11:40-11:55

**11:40-11:55** **Williamson 2201**

**Brandon Eschborn**
**Perfect Numbers in Other Bases**
Edinboro University of PA
Advised by: Dr. Frank Marzano

Perfect numbers have fascinated mathematicians for hundreds of years. However, there are properties that may not be as well known. This talk will explore three properties for even perfect numbers if expressed in a different number system.

**11:40-11:55** **Williamson 2202**

**Shannon Miller**
**Irreducible Representations of $S_4$ and $S_5$**
Youngstown State University
Advised by: Dr. Thomas Madsen

In this talk we will introduce the concept of an irreducible representation of a group. Specifically, we will consider the irreducible representations of $S_4$ and $S_5$. $S_4$ and $S_5$ have as many irreducible representations as the number of conjugacy classes. To understand what each representation looks like, we will calculate the characters. Various methods used to calculate each character will be discussed.

**11:40-11:55** **Williamson 2203**

**Kaila DeChristofaro and Jessica Lefler**
**Mathematics of Partial Least Squares Regression**
Slippery Rock University
Advised by: Dr. Dil Singhabahu

Partial least squares regression (PLSR) is currently an up-and-coming form of statistical analysis; some studies are being done on its uses in analyzing fMRI brain images. This project aims to determine the effectiveness of the PLSR model. Our data comes from the Maternal Health Project at the University of Pittsburgh, and we aim to determine if drug use during pregnancy has a long-term effect on children later in their lives. Standard multiple linear regression (MLR) has been performed on this data and has shown no statistical difference, which we hypothesize is because limitations of the MLR cause it to become an invalid model in this type of analysis and that PLSR can overcome these limitations. We will also study the mathematics involved with PLSR and run it on a few brain scans.

**11:40-11:55** **Williamson 2204**

**Dipesh Bhandari, Yogesh Sapkota, and Prinshep Yadav**
**A Game of Ecology**
Youngstown State University
Advised by: Dr. Paddy Taylor

Our presentation involves an analysis of the characteristics and the behavior of the dragons from the television series Game of Thrones. We have analyzed characteristics of the dragons such as their growth, body mass, wingspan, speed, and daily energy requirement. Also, through our model, we have endeavored to answer questions on their feasibility in today's world.

# Afternoon Session 12:50-1:05

**12:50-1:05** **Payton Kuhns** **Williamson 2201**

**A Rolling Die Game**

Youngstown State University

Advised by: Dr. Thomas Smotzer

In this talk, we will analyze a three person die rolling game that could theoretically last forever. We model the game with a Markov Process and find the probability of each player winning. We did a computer simulation of the game and then altered the game's rules to make the probability of each player winning the same.

**12:50-1:05** **Dylan Langharst** **Williamson 2202**

**Deriving Properties of the Hermite Orthogonal Polynomial Sequence with a Motivation in the Fourier Transform Eigenvector Problem**

Penn State Erie

Advised by: Dr. Daniel Galiffa

The Fourier Transform is a vital tool in both pure mathematics, such as functional analysis, and applied mathematics, such as signal analysis. In this talk, it will be shown that the eigenvectors of the Fourier Transform are the Hermite orthogonal polynomial sequence. Starting from base principles of the Fourier Transform, we will then cover the rudimentary properties of the Hermite polynomials from their Rodrigues formula, including orthogonality and the associated differential equation. Using the fact that commutative operators share an eigenspace, it will be shown that the Hermite orthogonal polynomials are the eigenvectors of a differentiable operator, which in turn shows that the Hermite orthogonal polynomials are the eigenvectors to the Fourier Transform.

**12:50-1:05** **Christopher Woolfork** **Williamson 2203**

**Underwriting for Life Insurance**

Kent State University

Advised by: Dr. Darci Kracht

Underwriting involves conducting research and assessing the degree of risk in each applicant or entity before assuming that risk. My research topic focuses on the different factors that underwriters look at when determining whether or not to accept a potential policyholder. In addition to that, underwriters also determine the premium if accepted as a policyholder.

# Afternoon Session 12:50-1:05 (continued)

**12:50-1:05** | **Gyaneshwar Agrahari** | **Williamson 2204**

**Integration Tricks**

Youngstown State University
Advised by: Dr. Paddy Taylor

Some integration tricks for alternative methods for integration by parts and trigonometric substitution are presented.

# Afternoon Session 1:10-1:25

**1:10-1:25** **Lincoln 2201**

**Mike Dahmen**
**Analyzing Correlations Coefficients**
**Spring Chance BQ2 Marathon**
Youngstown State University
Advised by: Dr. Thomas Wakefield

We complete an analysis of the Spring Chance BQ2 Marathon to identify the correlations of pacing profiles during the course of a marathon by using Pearson's $r$ correlation coefficient and Fisher's $z$-transformation to test for statistical significance between pacing profiles. We compare the male and female participants in the marathon to the population and find there was statistical significance between the first checkpoint and the 5th and the 6th checkpoints among others.

**1:10-1:25** **Williamson 2202**

**Samuel Hockenberry**
**Investigation of Ohio Adjudicated Youth Through Cluster Analysis**
Westminster College
Advised by: Dr. Carolyn Cuff

The Allegheny County Court System keeps records on all juvenile court cases, referrals, and accusations within Allegheny County. While the initial goals of this research were to identify common characteristics of dependent and adjudicated children within Allegheny County, the data requested from the Allegheny County Court System was denied. This denial lead into another interest-focusing on arrested and rearrested youth. In 2009, the University of Cincinnati Corrections Institute published a report on a new tool called the Ohio Youth Assessment System (OYAS) that identifies the needs and risks of juvenile offenders. This report describes five tools that make up the OYAS and their initial results on arrested and rearrested youth. This project uses the results of this report as a base to recreate representative data and discover new findings. Through cluster analysis we hope to identify common characteristics of arrested and rearrested youth to allow for more informed decisions concerning the health and safety of adjudicated youth.

**1:10-1:25** **Williamson 2203**

**Ankur Basu**
**Calculating Car Insurance Premiums**
Kent State University
Advised by: Dr. Darci Kracht

Car insurance rates depend on various factors. Not always does the more expensive car have higher insurance rate. In a lot of cases the same car might have different rates for different locations. In our presentation we look at each of these factors individually as we try to conclude which factors increase or decrease car insurance rates. We will look at individual case studies towards the end of the presentation which will bring all the factors together and help us validate our findings

**1:10-1:25** **Williamson 2204**

**Bryson Stemock**
**On the equitable total $(k+1)$-coloring of $k$-regular graphs (Coloring for Adults)**
Youngstown State University
Advised by: Dr. Anita O'Mellan

Graph theory is a field of mathematics students (high school, undergraduate, graduate, or otherwise) are often unfamiliar with through no fault of their own. My talk focuses on coloring, a field within graph theory, which I usually describe to people as being similar to Sudoku. This presentation and the results that I have produced will be easily understandable to children of all ages and degrees and I will assume no prior knowledge on the subject. Hope to see you there!

# Afternoon Session 1:30-1:45

**1:30-1:45** **Nathaniel Melnik** **Williamson 2201**

**Algorithmic Trading**

Siena Heights University

Advised by: Dr. Andrew-David Bjork

Trading algorithms are algorithms that are in charge of buying and selling a particle stock. The algorithms are based off of mathematical or statistical models that make the decision to either sell or buy the stock. I will be testing the effectiveness of the algorithms by back-testing them on the website `www.quantopian.com`. The effectiveness will be defined by return on investment, timeline of strategy, and the amount of trades placed by each strategy. Throughout this presentation I will break down the algorithms that form different trading strategies and explain them.

**1:30-1:45** **Patrick Cone** **Williamson 2202**

**Graceful Tree Conjecture**

Indiana University of Pennsylvania

Advised by: Dr. Rachelle Bouchat

In graph theory, a graph is just a collection of vertices (dots) and edges (line segments connecting the dots). My project focuses on the Graceful Tree Conjecture. This conjecture was posed by Alexander Rosa in a 1967 paper on graph theory. The Graceful Tree Conjecture states that every tree, which is a certain class of graphs, has a graceful labeling. Moreover, a graceful labeling is an assignment of the integers 0 to $n$ to the vertices of the graph so that the edges, when labeled by the absolute value of the difference of the integers placed on the end vertices, are labeled by the integers 1 to $n$. It should be noted that the Graceful Tree Conjecture remains an unsolved problem in mathematics, although there are several classes of graphs where the conjecture has been proven true. Since the beginning of my research, I have worked to understand the problem, generate many examples, and make a few conjectures regarding generalized labeling equations that should produce graceful labelings for specific classes of graphs. In this research, we have also been working to define when two graceful labelings of tree graphs can be modified to form a graceful labeling of the larger tree graph formed by combining the two smaller graphs together.

**1:30-1:45** **Taylor Sutton and Jeremy Sidoti** **Williamson 2203**

**Mortality Through the Ages**

Kent State University

Advised by: Dr. Darci Kracht

"Mortality Through the Ages" aims to answer a few common questions. What causes female life expectancy to be higher than males? Has female life expectancy always dominated male life expectancy? Mortality and life expectancy have been affected by many different factors throughout history that we will discuss.

**1:30-1:45** **Linyuan Yu** **Williamson 2204**

**Find the Exponential of a Matrix**

Penn State Erie

Advised by: Dr. Boon Ong

Finding the exponential of a matrix using spectral decomposition method is presented.

# Afternoon Session 1:50-2:05

**1:50-2:05** **Williamson 2201**

**Max Fisher**

**Linear and Logistic Regression of 2017 NFL Statistics**

Youngstown State University

Advised by: Dr. Lucy Kerns

Linear and Logistic regression of NFL statistics to see which variables correlate with average points scored throughout the regular season are presented and discussed.

**1:50-2:05** **Williamson 2202**

**David Berdik**

**Analyzing the Effectiveness of Using Character $n$-grams to Perform Authorship Attribution on Informal Documents in the English Language**

Duquesne University

Advised by: Dr. Patrick Juola

Authorship attribution is a subfield of natural language processing which can be applied to practical issues such as copyright disputes. While there are many different methods that can be used to perform such an analysis, the effectiveness of these methods varies depending on the material that is being analyzed as well as the parameters chosen for the selected methods. One of these methods involves using groups of $n$ consecutive characters, called character $n$-grams, where $n$ refers to the number of characters in the gram. For the purposes of this paper, we will refer to character $n$-grams simply as "$n$-grams." It is expected that $n$-grams of different lengths will vary in their accuracy of attributing the correct author to a questioned document. Specifically, it is expected that as $n$-grams become larger, performance will improve, reach a peak, and then begin to degrade.

Using Patrick Juola's Java Graphical Authorship Attribution Program, we performed two different types of analyses on Koppel Schler's blog corpus by taking all corpus entries with at least 300 sentences, separating their first 100 sentences and last 100 sentences into separate entries, and running $n$-gram tests from 1 to 50 to determine what an ideal size would be for performing authorship attribution using character $n$-grams. Based on the results of the two types of tests, we showed that contrary to the bell curve-like performance that was anticipated, $n$-gram accuracy peaks much earlier than was anticipated before beginning its decline on the first type of test and on the second type of test, $n$-gram accuracy is closer to what was expected, but the performance is not bell curve-like. Future work will involve performing character $n$-gram analyses on different types of documents as well as different languages to determine how much variance, if any, is present between languages.

**1:50-2:05** **Williamson 2203**

**Josie Sabatino**

**Expected Costs of Nursing Home Care**

Kent State University

Advised by: Dr. Darci Kracht

We were approached by a local attorney. We used Actuarial Mathematics as a foundation for our calculations in determining what one can expect to pay for nursing home care in Ohio. The costs are calculated as an Actuarial/Expected Present Value (APV) in order to compare across age groups and genders. Present value will allow for easy comparison and gives the costs in today's dollars.

**1:50-2:05** **Williamson 2204**

**Lulu Liu**

**Number Theory Applied to Encryption Methods**

Penn State Erie

Advised by: Dr. Boon Ong

I will present four encryption methods including Caesar Cipher, Hill's Cipher, RSA and ElGamal. By analyzing the how these methods work and comparing the difference between them, we will have a better understanding of the encryption algorithms.

# 2018 MCM / ICM - COMAP Modeling Problems

**Continuous Modeling (Problem A)**
**Game of Ecology**

In the fictional television series *Game of Thrones*, based on the series of epic fantasy novels *A Song of Ice and Fire*, three dragons are raised by Daenerys Targaryen, the "Mother of Dragons." When hatched, the dragons are small, roughly 10 kg, and after a year grow to roughly 30-40 kg. They continue to grow throughout their life depending on the conditions and amount of food available to them.

For the purposes of this problem, consider these three fictional dragons are living today. Assume that the basic biology of dragons described above is accurate. You will need to make some additional assumptions about dragons that might include, for example, that dragons are able to fly great distances, breathe fire, and resist tremendous trauma. As you address the problem requirements, it should be clear how your assumptions are related to the physical constraints of the functions, size, diet, changes, or other characteristics associated with the animals.

Your team is assigned to analyze dragon characteristics, behavior, habits, diet, and interaction with their environment. To do so, you will have to consider many questions. At a minimum, address the following: What is the ecological impact and requirements of the dragons? What are the energy expenditures of the dragons, and what are their caloric intake requirements? How much area is required to support the three dragons? How large a community is necessary to support a dragon for varying levels of assistance that can be provided to the dragons? Be clear about what factors you are considering when addressing these questions.

As with other animals that migrate, dragons might travel to different regions of the world with very different climates. How important are the climate conditions to your analysis? For example, would moving a dragon between an arid region, a warm temperate region, and an arctic region make a big difference in the resources required to maintain and grow a dragon?

Once your dragon analysis is complete, draft a two-page letter to the author of *A Song of Ice and Fire*, George R.R. Martin, to provide guidance about how to maintain the realistic ecological underpinning of the story, especially with respect to the movement of dragons from arid regions to temperate regions and to arctic regions.

While your dragon analysis does not directly apply to a real physical situation, the mathematical modeling itself makes use of many realistic features used in modeling a situation. Aside from the modeling activities themselves, describe and discuss a situation outside of the realm of fictional dragons that your modeling efforts might help inform and provide insight?

## Discrete Modeling (Problem B)
## Send in the Drones: Developing an Aerial Disaster Relief Response System

Background: In 2017, the worst hurricane to ever hit the United States territory of Puerto Rico left the island with severe damage and caused over 2900 fatalities. The combined destructive power of the hurricane's storm surge and wave action produced extensive damage to buildings, homes, and roads, particularly along the east and southeast coast of Puerto Rico. The storm, with its fierce winds and heavy rain, knocked down 80 percent of Puerto Rico's utility poles and all transmission lines, resulting in loss of power to essentially all of the island's 3.4 million residents. In addition, the storm damaged or destroyed the majority of the island's cellular communication networks. The electrical power and cell service outages lasted for months across much of the island, and longer in some locations. Widespread flooding blocked and damaged many highways and roads across the island, making it nearly impossible for emergency services ground vehicles to plan and navigate their routes. The full extent of the damage in Puerto Rico remained unclear for some time; dozens of areas were isolated and without communication. Demands for medical supplies, lifesaving equipment, and treatment strained health-care clinics, hospital emergency rooms, and non-governmental organizations' (NGOs) relief operations. Demand for medical care continued to surge for some time as the chronically ill turned to hospitals and temporary shelters for care.

Problem: Non-governmental organizations (NGOs) are often challenged to provide adequate and timely response during or after natural disasters, such as the hurricane that struck the United States territory of Puerto Rico in 2017. One NGO in particular–HELP, Inc.–is attempting to improve its response capabilities by designing a transportable disaster response system called "DroneGo." DroneGo will use rotor wing drones to deliver pre-packaged medical supplies and provide high-resolution aerial video reconnaissance. Selected drones should be able to perform these two missions–medical supply delivery and video reconnaissance–simultaneously or separately, depending on relief conditions and scheduling. HELP, Inc. has identified various candidate rotor wing drones that it would like your team to consider for possible use in designing its DroneGo fleet.

DroneGo's pre-packaged medical supplies, called medical packages, are meant to augment, not replace, the supplies provided by local medical assistance organizations on-site within the country affected by the disaster. HELP, Inc. is planning on three different medical packages referred to as MED1, MED2, and MED3. Drones will carry these medical packages within drone cargo bays for delivery to selected locations. Depending on the specific drone being used to transport medical supplies, it may be possible that multiple medical packages can be transported in a single drone cargo bay. Note that drones must land on the ground to offload medical supplies from the drone cargo bays. The video capability of the drones will provide high-resolution video of damaged and serviceable transportation road networks to HELP, Inc.'s command and control center for ground-based route planning. HELP, Inc. will use International Standards Organization (ISO) standard dry cargo containers to quickly transport a complete DroneGo disaster response system to a particular disaster area. The individual shipping containers for all drones in the DroneGo fleet, along with all required medical packages, must fit within a maximum of three of the ISO cargo containers to be delivered to a single location, or up to three different locations if three cargo containers are used in the disaster area. Each shipping container's contents should be packed in order to minimize any need for buffer materials for unused space.

HELP, Inc. is asking your team to use the 2017 situation in Puerto Rico to design a DroneGo disaster response system that will fit within the containers noted while meeting the anticipated medical supply demands during a potential similar future disaster scenario. It is possible that the demand requirements of this scenario may exceed the capabilities of the drone fleet your team identifies. If this occurs, HELP, Inc. wants to clearly understand any tradeoffs that it must make for implementing solutions to address these shortcomings.

**Part 1.** Develop a DroneGo disaster response system to support the Puerto Rico hurricane disaster scenario. Consider the background information, the requirements identified in the problem statement, and the information provided in the problem attachments to address the following.

1. Recommend a drone fleet and set of medical packages for the HELP, Inc. DroneGo disaster response system that will meet the requirements of the Puerto Rico hurricane scenario. Design the associated packing configuration for each of up to three ISO cargo containers to transport the system to Puerto Rico.
2. Identify the best location or locations on Puerto Rico to position one, two, or three cargo containers of the DroneGo disaster response system to be able to conduct both medical supply delivery and video reconnaissance of road networks.

3. For each type of drone included in the DroneGo fleet:
   (a) Provide the drone payload packing configurations (i.e. the medical packages packed into the drone cargo bay), delivery routes and schedule to meet the identified emergency medical package requirements of the Puerto Rico hurricane scenario.
   (b) Provide a drone flight plan that will enable the DroneGo fleet to use onboard video cameras to assess the major highways and roads in support of the Help, Inc. mission.

**Part 2.** Write a 1–2 page memo to the Chief Operating Officer (CEO) of HELP, Inc. summarizing your modeling results, conclusions, and recommendations so that she can share with her Board of Directors.

**Interdisciplinary Modeling (Problem E)**
**What is the Cost of Environmental Degradation?**

Economic theory often disregards the impact of its decisions on the biosphere or assumes unlimited resources or capacity for its needs. There is a flaw in this viewpoint, and the environment is now facing the consequences. The biosphere provides many natural processes to maintain a healthy and sustainable environment for human life, which are known as ecosystem services. Examples include turning waste into food, water filtration, growing food, pollinating plants, and converting carbon dioxide into oxygen. However, whenever humans alter the ecosystem, we potentially limit or remove ecosystem services. The impact of local small-scale changes in land use, such as building a few roads, sewers, bridges, houses, or factories may seem negligible. Add to these small projects, large-scale projects such as building or relocating a large corporate headquarters, building a pipeline across the country, or expanding or altering waterways for extended commercial use. Now think about the impact of many of these projects across a region, country, and the world. While individually these activities may seem inconsequential to the total ability of the biosphere's functioning potential, cumulatively they are directly impacting the biodiversity and causing environmental degradation.

Traditionally, most land use projects do not consider the impact of, or account for changes to, ecosystem services. The economic costs to mitigate negative results of land use changes: polluted rivers, poor air quality, hazardous waste sites, poorly treated waste water, climate changes, etc., are often not included in the plan. Is it possible to put a value on the environmental cost of land use development projects? How would environmental degradation be accounted for in these project costs? Once ecosystem services are accounted for in the cost-benefit ratio of a project, then the true and comprehensive valuation of the project can be determined and assessed.

Your ICM team has been hired to create an ecological services valuation model to understand the true economic costs of land use projects when ecosystem services are considered. Use your model to perform a cost benefit analysis of land use development projects of varying sizes, from small community-based projects to large national projects. Evaluate the effectiveness of your model based on your analyses and model design. What are the implications of your modeling on land use project planners and managers? How might your model need to change over time?

**2019 MCM-COMAP Participants from YSU**

| | |
|---|---|
| Bishal Lamichhane | Gyaneshwar Agrahari |
| Pradip Rimal | Subham Singh |
| Bikash Thapa | Luke Hetzel |
| Yogesh Sapkota | Zhihan Li |
| Dipesh Bhandari | Luke Pandy |
| Prinshep Yadav | Nishan Adhikan |

## 2019 PME National Meeting at MAA MathFest

Please join us at this year's meeting to be held July 31 through August 3, 2019, in Cincinnati, Ohio. Students are invited to give fifteen minute talks on any mathematical topic or application in areas such as statistics, computing, or operations research. Topics including expository research, interesting applications, problems, etc. are also welcome. Transportation reimbursement is also available to those who qualify. Visit the National Pi Mu Epsilon website at `http://www.math-pme.org` for more details.

## Ohio Section of MAA Spring Meeting at The University of Akron

The Ohio Section of the Mathematical Association of America will hold its annual spring meeting at The University of Akron on Friday, April 5 and Saturday, April 6, 2019. The meeting consists of talks by mathematics faculty, graduate students, and undergraduates from around the state. The Section especially welcomes talks and participation by undergraduate students. In addition to student talks, there is an undergraduate problem solving competition with cash prizes, and a pizza party. We encourage you to give a talk at the meeting or participate in the competition or pizza party.

If you are participating in the problem solving competition, we ask that you register at:

`http://constum.ohiomaa.org/`

If you have any questions, please do not hesitate to contact Tom Wakefield by phone `330-941-3302` or by email `tpwakefield@ysu.edu`.

## A Warm Welcome to the Participating Schools:

- Case Western Reserve University
- Chatham University
- Clarion University of Pennsylvania
- Cleveland State University
- Duquesne University
- Edinboro University of Pennsylvania
- Fairmont State University
- Indiana University of Pennsylvania
- iSTEM Geauga Early College High School
- Kent State University
- LaRoche College
- Lake Erie College
- Lakeland Community College
- Penn State Erie, The Behrend College
- Siena Heights University
- Slippery Rock University
- The University of Akron
- Westminster College
- Youngstown State University

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**Pi Mu Epsilon Faculty Advisors**

Dr. G. Jay Kerns

Dr. Alicia Prieto Langarica

Dr. Thomas Madsen

Dr. Thomas Wakefield

Dr. George Yates

Funding for this conference is provided by the YSU Student Government Association, College of STEM, and National Pi Mu Epsilon Honor Society.

Special thanks to National PME, YSU President Tressel, Dr. Wim Steelant, YSU Student Government, the College of STEM, the Department of Mathematics and Statistics, and the Center for Undergraduate Research in Mathematics (CURMath) at Youngstown State University.