2023 PME Conference Schedule

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

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

Matthew Commons, YSU PME Chapter Vice-President

	Williamson 2212	Williamson 2205
10:20-10:35	Richard Williams and Davis Funk	COMAP-MCM
10:40-10:55	Lucy Allen	COMAP-MCM
11:00-11:15	Brenna Nurenberg	COMAP MCM
11:20-11:35	Nikitas Missos and Colin Faloon	COMAP MCM
11:40-11:55	Michael Gilbert	COMAP MCM

11:55–12:50: Lunch - Williamson 3422/3423

	Williamson 2212
12:50-1:05	James Iler
1:10-1:25	Liam Yates
1:30-1:45	Renxuan Liu
1:50-2:05	Jacek Strotz

2:10: Closing Remarks - Williamson 3422/3423

Morning Session 10:20-10:35

10:20-10:35 | **Williamson 2212**

Richard Williams and Davis Funk

Linear Quadratic Pursuit-Evasion Games on Time Scales

Fairmont State University
Advised by: Dr. Nick Wintz

In 1988, Stefan Hilger initiated the theory of dynamic equations on time scales, which seeks to unify and extend discrete and continuous analysis. As a result, we can generalize a process that accounts for both cases, or any combination of the two provided that we restrict ourselves to closed, nonempty subsets of the reals (a time scale). Consequently, we have a formal way of studying the behavior of hybrid discrete-continuous systems. Since its inception, researchers have found applications of time scales in topics such as heat transfer, population dynamics, and economics. In fact, it could be applied to any discipline that demands for the modelling of both discrete and continuous data. We are introduced to a new definition of both the derivative and the integral and are left with the opportunity to apply it to other systems. The linear quadratic regulator (LQR) is a useful tool in optimal control theory. The LQR seeks to find an optimal control that minimizes an associated quadratic cost functional. One application of interest is in noncooperative game theory known as linear quadratic pursuit-evasion games (LQPEG). Here, the are two players–an evader that seeks to minimize the cost functional and a pursuer that seeks to maximize it. These types of problems can model a variety of situations. For instance, the evader may be a drone which would like to minimize the use of its battery while a missile guidance system would like to maximize the use of the droneâs battery. Solutions to these problems are saddle points: comprised strategies where the system would go in favor of the other player if one player altered their strategy. Here, we extend the LQPEG onto time scales. Consequently, we can determine the saddle point strategies for the LQPEG in not only the discrete and continuous cases, but also hybrid cases. This includes the time scale of quantum numbers, scalars of the integers, or the union of several open or closed intervals in the reals.

10:20-10:35 | **COMAP Modeling Discussion** | **Williamson 2205**

All are welcome to discuss this year's COMAP problems and potential solutions to both the discrete and continuous problems. This informal session is meant to share ideas and strategies for the approach to the problems, which are provided on Page 7 of this abstract book.

Morning Session 10:40-10:55

10:40-10:55 | **Lucy Allen** | **Williamson 2212**

Graph Theoretic Approach to DNA Self-Assembly

Youngstown State University

Advised by: Dr. Alexis Byers

Modeling self-assembling DNA structures is a rapidly growing area due to improvements in nanotechnology, and can be used to construct synthetic self-assembling DNA structures, which can in turn lead to more effective treatments and diagnosis of diseases. One way to model the DNA structure is with a graph structure. We can imagine strands of DNA as branches meeting at a single point, called a node. These strands have sequences of the four bases attached to them, which determine which other branches they can bond to according to the Watson-Crick model for complementary pairings of the four bases. When the strands bond, they form an edge. Since these branched molecules are expensive and difficult to construct, the main problem is to minimize how they bond in a specified way and under increasingly restrictive constraints.

10:40-10:55 | **COMAP Modeling Discussion** | **Williamson 2205**

All are welcome to discuss this year's COMAP problems and potential solutions to both the discrete and continuous problems. This informal session is meant to share ideas and strategies for the approach to the problems, which are provided on Page 7 of this abstract book.

Morning Session 11:00-11:15

11:00-11:15 | **Brenna Nurenberg** | **Williamson 2212**

Optimal Decisions for Competitive Feeding While Accounting for Preference

Siena Heights University

Advised by: Dr. Nate Iverson

We are looking at a competitive feeding ranked preference problem. These problems look at players who choose between multiple food sources and split the reward if they choose the same source. We also consider the costs associated with traveling to the food source and the player preferences that can increase or decrease the reward's value. As a case study, we examine a situation in which two elephants choose between three different food sources and find an optimal strategy for each preference multiplier.

11:00-11:15 | **COMAP Modeling Discussion** | **Williamson 2205**

All are welcome to discuss this year's COMAP problems and potential solutions to both the discrete and continuous problems. This informal session is meant to share ideas and strategies for the approach to the problems, which are provided on Page 7 of this abstract book.

Morning Session 11:20-11:35

11:20-11:35 | **Nikitas Missos and Colin Faloon** | **Williamson 2212**

Fair Odds Projections in Horse Racing

Youngstown State University
Advised by: Dr. Moon Nguyen

In this project, we will predict the fair odds of a horse race. The fair odds value is a calculated ratio based on historical factors pertaining to specific horses. The factors included: the number of races, average finish position, and speed measure. The predicted fair odds allow gamblers to predict the probability of winning a given horse in a race. In a live race, the gambler will compare the predicted fair odds to the live odds, provided by the bookmaker, to decide what horse to bet.

11:20-11:35 | **COMAP Modeling Discussion** | **Williamson 2205**

All are welcome to discuss this year's COMAP problems and potential solutions to both the discrete and continuous problems. This informal session is meant to share ideas and strategies for the approach to the problems, which are provided on Page 7 of this abstract book.

Morning Session 11:40-11:55

11:40-11:55 | **Michael Gilbert** | **Williamson 2212**

Patterns in Residue Designs

Pennsylvania Western University–Clarion
Advised by: Dr. Michael McConnell

This presentation investigates various patterns present in residue designs. The presentation first goes over clock arithmetic, a tool used to understand modular arithmetic. The presentation investigates some properties of modular arithmetic, the mathematical basis for residue designs. Residue designs are constructed in the presentation, and various kinds are explored. Finally, the presentation connects the patterns in residue designs to properties in modular arithmetic and proves those relationships.

11:40-11:55 | **COMAP Modeling Discussion** | **Williamson 2205**

All are welcome to discuss this year's COMAP problems and potential solutions to both the discrete and continuous problems. This informal session is meant to share ideas and strategies for the approach to the problems, which are provided on Page 7 of this abstract book.

Afternoon Session 12:50-1:05

12:50-1:05 | **James Iler** | **Williamson 2212**

Linearized Polynomials over Finite Fields
Cleveland State University
Advised by: Dr. Leah Gold

In the research areas of Cryptography and Coding Theory, an algebraic structure known as the finite field appears frequently. This talk will provide a brief overview of the notions necessary to define such an object, from the fields of prime order to their extensions of arbitrary degree. We discuss some properties of the arithmetic in such fields, which are used to define an important polynomial known as the trace. Following this, the more general class of linearized polynomials is introduced, which carries an algebraic structure of its own. Finally, we briefly describe an application of the trace in Coding Theory, which can be generalized to all linearized polynomials.

Afternoon Session 1:10-1:25

1:10-1:25 | **Liam Yates** | **Lincoln 2212**

Generating the Patterns of Root Finding Methods
University of Pittsburgh at Greensburg
Advised by: Dr. Gary Hart

Using a program to run the Newton's method repeatedly until a root is found, it enables to the possibility to generate a picture in a given space on the complex plane of what points converge to what other points and how many iterations of the function needed to run to get those points to that (or those) roots.

Afternoon Session 1:30-1:45

1:30-1:45 | **Renxuan Liu** | **Williamson 2212**

Chaos Theory: Lorenz Butterfly
University of Pittsburgh at Greensburg
Advised by: Dr. Gary Hart

Why is chaos theory is an important tool to predict weather? We will introduce and give some history of the Lorenz attractor which is part of chaos theory, and finally explain why the initial condition so important.

Afternoon Session 1:50-2:05

1:50-2:05 | **Williamson 2212**

Jacek Strotz

Solving Scramble Squares using Binary Representation and Bitwise Operations

University of Mount Union
Advised by: Dr. Katie Ritchey

The Scramble Squares puzzle is a 3-by-3 grid of squares, each with four images on its sides. The photos are split into halves, and two must be matched together. A finished puzzle would be one where every pair of touching sides forms a completed image, formed by two complementary halves. In search of the fastest algorithm, I compare different applications of object-oriented programming to binary representation. A table of averaged execution times proves that, in this case, the binary method is more efficient. The price of higher efficiency is increased programming difficulty, as the programmer must have a deep understanding of bitwise operations. However, where efficiency is paramount, this remains a simple task.

2023 MCM / ICM - COMAP Modeling Problems

Continuous Modeling (Problem A)
Drought-Stricken Plant Communities

Different species of plants react to stresses in different ways. For example, grasslands are quite sensitive to drought. Droughts occur at varying frequencies and varying levels of severity. Numerous observations suggest that the number of different species present plays a role in how a plant community adapts when exposed to cycles of drought over successive generations. In some communities with only one species of plant, the generations that follow are not as well adapted to drought conditions as the individual plants in communities with four or more species. These observations raise many questions. For example, what is the minimal number of species necessary for a plant community to benefit from this type of localized biodiversity? How does this phenomenon scale as the number of species increases? What does this imply for the long- term survivability of a plant community?

Considering the relationship of drought adaptability with respect to the number of species in a plant community, your task is to explore and better understand this phenomenon. Specifically, you should:

- Develop a mathematical model to predict how a plant community changes over time as it is exposed to various irregular weather cycles. Include times of drought when precipitation should be abundant. The model should account for interactions between different species during cycles of drought.
- Explore what conclusions you can draw from your model with respect to the long-term interactions of a community of plants and the larger environment. Consider the following questions:
- How many different plant species are required for the community to benefit and what happens as the number of species grows?
- How do the types of species in the community impact your results?
- What are the impact of a greater frequency and wider variation of the occurrence of droughts in future weather cycles? If droughts are less frequent, does the number of species have the same impact on the overall population?
- How do other factors such as pollution and habitat reduction impact your conclusions?
- What does your model indicate should be done to ensure the long-term viability of a plant community and what are the impacts on the larger environment?

Discrete Modeling (Problem B)
Reimagining Maasai Mara

Kenya's wildlife preserves were originally created primarily to protect wildlife and other natural resources. Kenya's parliament passed the Wildlife Conservation and Management Act, 2013 to provide more equitable sharing of resources, as well as to allow alternative, community-based management efforts. Kenya has since added amendments to address gaps in the legislation to provide more clear governance, finance, and penalties for violators.

Focusing on one large game preserve, the Maasai Mara, your task is to determine alternate ways to manage the resources within and outside the current boundaries of the park. Specifically, you should:

- Consider and recommend specific policies and management strategies for different areas within the current preserve that will protect wildlife and other natural resources while also balancing the interests of the people who live in the area. These policies and strategies should help mitigate the impacts of lost opportunities experienced by the people who live near the preserve, as well as minimize negative interactions between animals and the people attracted to the preserve.
- Develop and describe a methodology to determine which policies and management strategies will result in the best outcomes. Your report should discuss how to rank and compare outcomes from your methodology. Be sure to include descriptions and analyses of the models used to predict the interactions between animals and people, as well as the resulting economic impacts in the area within and around the preserve.
- Given your proposed plan, provide predictions about the long-term trends that will result from your recommendations. Analyze and provide estimates of the certainties and impacts of the possible long-term outcomes. You should also describe how your approach could be applied to other wildlife management areas.
- Finally, provide a two-page non-technical report for the Kenyan Tourism and Wildlife Committee discussing your proposed plan and its value for the preserve.

Interdisciplinary Modeling (Problem E)
Light Pollution

Light pollution is used to describe any excessive or poor use of artificial light. Some of the phenomena that we refer to as light pollution include light trespass, over-illumination, and light clutter. These phenomena are most easily observed as a glow in the sky after the sun has set in large cities; however, they may also occur in more remote regions. Light pollution alters our view of the night sky, has environmental impacts and affects our health and safety. For example, plant maturation may be delayed or accelerated, and migration patterns of wildlife affected. Excessive artificial light may confuse our circadian rhythms, leading to poor sleep quality and perhaps physical and mental health issues. Glare caused by artificial lights may contribute to some motor vehicle accidents. Community officials or local groups may implement intervention strategies to mitigate the negative effects of light pollution. Artificial light, however, has both positive and negative effects that impact different locations in different ways. For example, to avoid the negative impacts of light pollution listed above, some communities opt for low-light neighborhoods which in turn might lead to increased crime. The impacts of light pollution may depend on factors such as the location's level of development, population, biodiversity, geography, and climate. Therefore, assessing the extent of the effects and the potential impacts of any intervention strategies must be tailored to a specific location.

COMAP's Illumination Control Mission (ICM) is working to promote awareness of the impacts of light pollution and develop intervention strategies to mitigate those impacts. In support of this ICM work, your task is to address measuring and mitigating the effects of light pollution in various locations, incorporating both human and non-human concerns. Specifically, you should:

- Develop a broadly applicable metric to identify the light pollution risk level of a location.
- Apply your metric and interpret its results on the following four diverse types of locations:
  - a protected land location,
  - a rural community,
  - a suburban community, and
  - an urban community.
- Describe three possible intervention strategies to address light pollution. Discuss specific actions to implement each strategy and the potential impacts of these actions on the effects of light pollution in general.
- Choose two of your locations and use your metric to determine which of your intervention strategies is most effective for each of them. Discuss how the chosen intervention strategy impacts the risk level for the location.
- Finally, for one of your identified locations and its most-effective intervention strategy, produce a 1-page flyer to promote the strategy for that location.

2023 MCM-COMAP Participants from YSU

Nicholas VanSuch Sunil Tiwari Anjan Lamsal	Shreejan Bhandari Sandeep Pradhan
Aaron Groner Alex Corona Jayanta Pandit	Saverio Mignella Joseph Macejko Lydia Noble
Thomas Hunyadi Ben Blasko Jack Hamilton	Aayush Kumar Singh Bijay Thakur

Ohio Section of MAA Spring Meeting at Baldwin Wallace

The Ohio Section of the Mathematical Association of America will hold its annual spring meeting at Baldwin Wallace University on Friday, March 31 and Saturday, April 1, 2023. 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:

- Cleveland State University
- Fairmont State University
- Kent State University
- Lakeland Community College
- Pennsylvania Western University - Clarion
- Siena Heights University
- University of Mount Union
- University of Pittsburgh at Greensburg
- Youngstown State University

YSU Pi Mu Epsilon Officers

President: Sarah Rambo

Vice President: Matthew Commons

Secretary: Sean Livingston

Treasurer: Patrick Monahan

Historian: Victoria Messuri

Pi Mu Epsilon Faculty Advisors

Dr. Alexis Byers

Dr. G. Jay Kerns

Dr. Alicia Prieto Langarica

Dr. Thomas Madsen

Dr. Thomas Wakefield

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