COLLEGE OF Saint Benedict Saint John's UNIVERSITY

SPRING 2024 PI MU EPSILON CONFERENCE PROGRAM

All presentations will occur in **PENGL** on the Saint John's University campus. Below is the schedule of talks, with room information and Zoom links provided, followed by the abstracts (beginning page 2) for each talk. The Zoom information has also been posted to the conference webpage.

SCHEDULE FOR FRIDAY, APRIL 12.

Student research presentations:

Time	PENGL 229	PENGL 232
6:30-6:55pm	Lauren Scheurer, Sumer Harrington Sophia Sibell, Natalie Williams	Cameron Hahnfeldt
7:00-7:35pm	Ethan Engh	Jacob Gathje
7:30-7:55pm	Aidan Thomas	Fiona Smith

Keynote Address #1: Dr. Lew Ludwig
Time: 8:30pm - 9:30pm CST
Room: PENGL 269 (or via Zoom)

SCHEDULE FOR SATURDAY, APRIL 13.

Open problem session: Breakfast with a side of math
Time: 8:00am - 8:55am CST
Room: PENGL 269

Student research presentations:

Time	PENGL 229	PENGL 232
9:00-9:25am	Emily Liddell, Matej Kozanek	Ivie Taft
9:30-9:55am	Ben Suo	Ritwik Gaur

Keynote Address #2: Dr. Lew Ludwig
Time: 10:30am - 11:30am CST
Room: PENGL 269 (or via Zoom)

PRESENTATION ABSTRACTS - FRIDAY APRIL 12.

Student presentation - Friday, April 12, 6:30pm in PENGL 229.
Speaker: Lauren, Scheurer, Sumer Harrington, Sophia Sibell, Natalie Williams (College of Saint Benedict and Saint John's University)
Illuminate: A Game Played on Graphs - We will study the game *Illuminate*. This is a game played between two players. The idea is that there are a lot of lightbulbs in a large warehouse, and they take turns turning a light bulb on. When a light bulb is turned on, it illuminates the area directly under it as well as the areas immediately surrounding it. The player who is the one to make all of the warehouse illuminated is the winner. This can be modeled on a graph. The two players take turns (1) selecting a vertex that has not yet been illuminated and (2) coloring that vertex and its immediate neighbors. The last player to move wins. After an introduction to the game, we will summarize our results on graphs of nested cyclic graphs that resemble spider webs.

Student presentation - Friday, April 12, 6:30pm in PENGL 232.
Speaker: Cameron Hahnfeldt (College of St. Benedict and St. John's University)
Symmetric Groups Acting on ℓ-sets - Bases are compilations of sets containing elements of symmetric groups such that moving one element to another element causes a change in at least one of the sets. Considering that swapping two elements must change a set in some way, each base needs to be structured such that elements that appear together in a set must also appear in separate sets in order for the overall base to change. Each change in the base shows exactly what action took place. We go through a method that will create a base given any symmetric group acting on any set size. The objective is to make bases that have the least number of sets in them and write a program in GAP that will produce those bases.

Student presentation - Friday, April 12, 7:00pm in PENGL 229.
Speaker: Ethan Engh (College of St. Benedict and St. John's University)
Games on Platonic Solids and Symmetric Groups - This research is a continuation of research done by Emily Twardy in Spring 2021 titled "Games on the Dihedral Group," which had two people playing 'Return' or 'Move' on the dihedral group of size n. Each vertex is distinguished by a unique number 1 through n. Players take turns choosing the symmetries of the respective dihedral group to move the vertices relative to the original positions. Player 1, known as Alpha, wins in 'Return' if vertex 1 ends where it started and wins in 'Move' if vertex 1 ends anywhere other than its original position. The research done in Summer 2023 applies this method to the Platonic solids (alternating groups of size 4, 8, and 12 for the tetrahedron, cube, and icosahedron, respectively) and the Symmetric groups. Additional work was done with the wreath product $Z_n \wr S_k$.

Student presentation - Friday, April 12, 7:00pm in PENGL 232.
Speaker: Jacob Gathje (College of St. Benedict and St. John's University)
The Sandpile Group of Subset Intersection Graphs - For integers $0 \leq \ell \leq kr \leq kc \leq n$, we give a description for the Smith group of the incidence matrix with rows (columns) indexed by the size kr (kc, respectively) subsets of an n-element set, where incidence means intersection in a set of size ℓ. This generalizes work of Wilson and Bier from the 1990s which dealt only with the case where incidence meant inclusion. Our approach also describes the Smith group of any matrix in the $\mathbb{Z}$-linear span of these matrices so includes all integer matrices in the Bose-Mesner algebra of the Johnson association scheme: for example, the association matrices themselves as well as the Laplacian, signless Laplacian, Seidel adjacency matrix, etc. of the associated graphs. In particular, we describe the critical (also known as sandpile) groups of these graphs. The complexity of our formula grows with the k parameters, but is independent of n and ℓ, which often leads to an efficient algorithm for computing these groups. We illustrate our techniques to give diagonal forms of matrices attached to the Kneser and Johnson graphs for subsets of size 3, whose invariants have never before been described, and recover results from a variety of papers in the literature in a unified way.

Student presentation - Friday, April 12, 7:30pm in PENGL 229.
Speaker: Aidan Thomas (College of St. Benedict and St. John's University)
Games on More than Dihedral Groups - In this talk we will discuss a pair of games played on groups. The games consist of two players picking symmetries of a group and applying them sequentially. Once all the symmetries have been used, the game ends and then we can determine which player won. We will discuss the results that I was able to produce this past summer, expanding upon research done in "Games On Dihedral Groups," by Emily Twardy.

Student presentation - Friday, April 12, 7:30pm in PENGL 232.
Speaker: Fiona Smith (College of St. Benedict and St. John's University)
A McEliece Cryptosystem, Using Permutation Error-Correcting Codes - Using existing methods of cryptography, we can encrypt messages through the internet. However, these methods are vulnerable to attacks done by a quantum computer, which are a rising threat to security. In this talk we will discuss a possible method of encryption, secure against quantum attacks, using permutation groups and coding theory.

Keynote Address #1 - Friday, April 12, 8:30pm in PENGL 269.
Speaker: Dr. Lew Ludwig (Denison University)
Generative AI in Education: Opportunities, Challenges, and Ethical Implications - This presentation will delve into generative artificial intelligence, focusing on large language models like Bard, Bing, and ChatGPT. Insightful survey data on the current use of Artificial Intelligence (AI) in educational contexts will be examined, underscoring its rapid emergence as a foundational element in contemporary teaching. We will discuss practical strategies for college math professors, high school instructors, and undergraduate students to incorporate AI into their educational practices effectively. Additionally, we will address the limitations of generative AI, paying particular attention to the ethical and equity issues it presents. The talk will conclude by analyzing AI's path forward and how it will affect math education. Participants will depart with an enhanced understanding of AI's educational possibilities and practical insights for leveraging this technology to augment their teaching and learning experiences.

PRESENTATION ABSTRACTS - SATURDAY APRIL 13.

Student presentation - Saturday, April 13, 9:00am in PENGL 229.
Speaker: Emily Liddell, Matej Kozanek (Concordia - Moorhead)
A Virtual Tool for Virtual Knots - Knot theory is broadly the study of knots. Knot theory is a subfield of low-dimensional topology with connections to quantum field theory, disentangling DNA strands, optimization of quantum computing, and many more. Virtual Knot theory was only introduced in 1999, and, as such, there are large research gaps in the field. One such gap in the research is the lack of a web tool to algorithmically determine knot invariants, or ways to tell if two knots are different from each other, based on user input. While online tables of knot invariants exist, such as Jeremey Green's Virtual Knot Table, they are not interactable, nor do they calculate any knot invariants based in user input. We aimed to fill this gap with our research to create a web tool that calculates a variety of knot invariants for any knot the user can dream up. The site computes invariants such as the Alexander Polynomial, P-Colorability, Odd Writhe, and more. We used a variety of programing languages to create this tool including Python, JavaScript, and PHP. The algorithm we created calculates knot invariants and stores these on a database to build a robust table of invariants. This website is a publicly available tool with the ability to both calculate invariants and display static tables of knots in the vein of other web resources.

Student presentation - Saturday, April 13, 9:00am in PENGL 232.
Speaker: Ivie Taft (Augsburg University)
Deformations on a Beam: Computational Approximation - The Beam Problem is physics theory with important implementations in engineering, as it allows engineers to understand the stability of their construction with different materials and shapes. My partner and I used four separate implementations of this problem, using H-Beam and I-Beam cross-sectional designs for a beam made of aluminum, each with Fixed-Free and Fixed-Pinned configurations. In doing so, we were able to analyze the order of convergence of the max error from the discretization of the force of gravity along a beam. By using Gaussian Elimination on the penta-diagonal matrix resulting from a derived approximation of the fourth derivative of our beams deflection, and comparing to the exact calculated results, we found a relationship between the error and the discretizing value. Through this method, we found an order of convergence of 2 for the error in respect to the discretizing distance.

Student presentation - Saturday, April 13, 9:30am in PENGL 229.
Speaker: Ben Suo (Saint John's Prep)
Fair Division - How do you share a cake among you and all your friends so that everyone feels like they've gotten their fair share of cake? How "fair" can you be? What does "fair" even mean? We'll talk about these and other related questions about how to divide resources and share things.

Student presentation - Saturday, April 13, 9:30am in PENGL 232.
Speaker: Ritwik Gaur (UMN Twin Cities, Wayzata High School)
When Are Satellite Orbits Stable? - In this talk, we delve into the captivating field of dynamical systems by examining the behavior of satellites in a gravitational field. We investigate what happens to a pinwheel-point mass configuration (representing a satellite orbiting a body in the universe) along its orbit. Join us as we find which configurations lead to equilibria and uncover criteria for stable orbits.

Keynote Address #2 - Saturday, April 13, 10:30am in PENGL 269.
Speaker: Dr. Lew Ludwig (Denison University)
Mathematical research - it's knot what you think! - Take a length of rope, tangle it up, then glue the loose ends together. This is a mathematical knot. In this presentation, we will consider the history and development of mathematical knot theory, as well as its surprising applications. We will also explore a specific branch of knot theory known as mosaic knots, which were first conceived in 2008. We will pose a number of accessible questions about mosaic knots that would be suitable for undergraduate research in mathematics or computer science. This presentation is intended for a general audience.