Philadelphia Undergraduate Mathematics Conference
April 1, 2023

The conference will be held in Rutgers-Camden Law School Building. All talks and the panel discussion are in Room 106. Room 103 is also available for discussions and breakout sessions. Registration, breakfast, lunch, poster session, and reception will be held in Room E200-Clark Commons (Bridge). Free parking is available in Lots C1, C2, C3 and C14. See the attached campus map for details.

Schedule:

9:00 AM: Registration/Breakfast/Coffee
9:20 AM: Welcome and Opening Remarks: Rutgers-Camden Provost Donna Nickitas
9:30 AM—10:15 AM: Plenary Lecture I: Benedetto Piccoli (Rutgers-Camden)
10:25 AM—11:10 AM: Plenary Lecture II: Ximena Catepillán (Millersville)
11:20 AM—12:00 PM: Student Talks:

- 11:20 AM—11:35 AM: Brandon Calia (Temple)
- 11:40 AM—11:55 AM: David Yang/Mengyuan Yang (Swarthmore)

12:00 PM—1:00 PM: Lunch and Poster Session, with posters by:

- Elizabeth Abt-Fraioli (Temple)
- Ryan Delorenzo (Rutgers-Camden)
- Christopher Heitmann (Temple)
- Nia Hernandez (Bryn Mawr)
- Felicia Pursner (Bryn Mawr)
- Nicholas Radley (La Salle)
- Noah Salewski (Gettysburg)
- Anthony Sbarra (Rutgers-Camden)

1:00 PM—2:00 PM: Student Talks:

- 1:00 PM—1:15 PM: Jacob Terkel (Gettysburg)
- 1:20 PM—1:35 PM: Dean Quach (Temple)
- 1:40 PM—1:55 PM: Tahda Queer (CUNY-Hunter)
- 2:00 PM—2:15 PM: Samuel Hsiao (Rutgers-Camden)

2:20 PM—3:05 PM: Plenary Lecture III: Philip Gressman (U Penn)
3:15 PM—4:00 PM: Exploring Careers in Mathematics Panel Discussion, with panelists:

- Hussein Awala, Portfolio Analytics Specialist, PNC Bank, Temple alumni
- Robin England, Market Vice President, New York Life, Rutgers-Camden alumni
- Haydee Herrera-Guzman, Graduate Program Director, Math, Rutgers-Camden

- Martin Lorenz, Former Graduate Program Director, Math, Temple University
- Eric Miller, Data and Performance Analyst, Lockheed Martin, Temple alumni
- Karen Walkinshaw, Math and Sciences (Grades 9-12), Camden City School District
- Lynne Price-Jones, Math and Sciences (Grades 1-8), Camden City School District
- Samantha Wert, Operations Analyst, Susquehanna International Group, Temple alumni

4:00 PM—5:00 PM: Reception

Talk Titles and Abstracts:

Plenary Lectures:

Ximena Catepillán: Ethnomathematics: The connection between culture, history, and mathematics

For over 15 years, I have traveled to remote places with Dr. Edwin Barnhart, founder and Director of the Maya Exploration Center, and his team to do archaeological studies associated with ethnomathematics, the connection between culture, history, and mathematics. In this presentation, I will provide examples of ethnomathematics that I taught in an undergraduate course, as well as in a first-year seminar on the mathematics of pre-Columbian Americas.

Philip Gressman: How big can it be? Quantifying size in Fourier analysis

In this talk I will discuss a few problems of quantifying the notion of size in the mathematical area of Fourier analysis. The fundamental issue is that in essentially any sufficiently complex system, there are multiple "natural" ways to understand or quantify the notion of size. This leads to a never-ending series of questions in comparing different notions, like: does largeness in one sense always lead to largeness in the other sense? The main part of the talk will be about the Kakeya Needle Problem, which examines whether sets which are large enough to move a needle-shaped object around inside must also be large in the usual sense of area. This problem has an interesting and satisfying solution, but is also intimately connected to a host of open questions, large and small, in Fourier analysis. As time permits, we will explore connections to geometric nonconcentration inequalities, which are a general framework for figuring out how to define largeness of sets so that it corresponds with whatever geometric properties that you find interesting.

Benedetto Piccoli: Math everywhere: How mathematics is used in real-life situations

We show how math appears in every aspect of our daily life. First, we describe how math is used in biomedicine as alternative to experimental methods, such as clinical trials. Some examples of collaboration with pharma industries are described. Then we focus on vehicular traffic and illustrate the math behind the world largest experiments with autonomous vehicles.

Student talks:

Brandon Calia: Ranked choice voting methods and the frequency of their agreement
In ranked preference elections, voters are given a set of candidates which they may rank in their preferred order. However, there are different counting methods that may be used to select the winner, and these methods may disagree when processing the same set of ballots. We wish to estimate the probability that these methods will disagree in typical ranked preference elections. We gathered data from over 100 real ranked preference elections, measuring the frequency of method agreement and informing the parameters for our simulations. In simulating these elections with an advanced spatial model, we estimate the frequency of method disagreements and determine characteristics of these disagreements.

Samuel Hsiao: Multiplicities of eigenvalues for the Laplace operator
It is known that frequencies of the vibration of a drumhead are determined by eigenvalues of the Laplace operator subject to the Dirichlet boundary condition. As such, finding the multiplicity of an eigenvalue of the Dirichlet Laplacian is a question of interest. In this talk, we will study multiplicities of eigenvalues of the Dirichlet Laplacian on a rectangle. This problem is related to counting the number of integer lattice points on a circle in the first quadrant. Here we will prove that on a square, for any given positive integer, there is an eigenvalue with multiplicity of this given integer. This talk is a preliminary report on a project with Jack Heimrath under the supervision of Dr. Siqi Fu.

Dean Quach: Another constraint on the perfect cuboid
The Perfect Cuboid is a problem where we try to find if there exists a cube with an integer edges, face diagonals and space diagonal. As of 2023, it is still unsolved and has not been proven to exist or cannot exist.

We have found another constraint on the divisibility of the product of all edges, face diagonals and space diagonal. This new constraint gives more reason to believe that the perfect cuboid may not exist.

Tahda Queer: Local behavior of the Eden model on graphs and tessellations of manifolds
I would be happy to present our research project, which has some flavors of probability, combinatorics, geometric group theory and topology, in an accessible way using illustrations and animation (see our preprint for more technical details: https://arxiv.org/abs/2212.14146).

Jacob Terkel: On maximum size zero-h-sum-free sets in cyclic groups
We say that a set is zero-h-sum-free in an additively written abelian group G if there is no way to write the identity element of G as the sum of h (not necessarily distinct) elements of the aforementioned set. We are able to study such sets with methods previously utilized by Bajnok,

Matzke, Hamidoune, and Plagne. Using these techniques alongside novel ones we are able to determine the maximum size of a zero-h-sum-free set in all cyclic groups as well as an infinite number of non-cyclic groups for all positive integer values of h.

David Yang: Circle packings from tilings of the plane

Any circle configuration has a tangency graph, with a vertex for each circle and an edge for each tangency between circles. The well-known Apollonian circle packing can be constructed from a set of four base circles and a set of four dual circles, each of which has tetrahedral tangency graphs. The orbit of the base circles under the group generated by reflections through the dual circles is the packing, an infinite fractal set of circles.

In general, one can start with a finite set of base circles whose tangency graph is the graph of any polyhedron and a finite set of dual circles whose tangency graph is the graph of the dual polyhedron. The orbit of the base circles under the group generated by the dual circles is known as a polyhedral packing, defined by Kontorovich and Nakamura.

We study packings which originate from infinite configurations of base and dual circles, a further generalization. We introduce a new class of fractal circle packings in the plane and discuss its relation to crystallographic and Klenian circle packings. The existence and uniqueness of these packings are guaranteed by infinite versions of the Koebe-Andreev-Thurston theorem.

The three main circle packings we study are the triangular, square, and hexagonal packings. We focus on their arithmetic properties--integrality, super-integrality, and quadratic and linear forms. We also give a broader class of examples (trapezohedron, cupola, and anticupola circle packings), with a focus on symmetries. We prove structure theorems which give a complete description of the symmetry groups for these packings and show that all 17 wallpaper groups appear in the symmetry groups of our packings. The infinite circle packings we study may reveal number theory and group theory properties of great interest, which remain to be further explored.