

 Program for Research in
Mathematics, Engineering and Science



Photo: Slava Gerovitch

**Sixteenth Annual
Spring-Term
PRIMES Conference
May 17, 2026**

Sunday, May 17

Mathematics

Room 2-190, MIT

9:30 am: Welcoming Remarks

- Prof. Pavel Etingof, PRIMES Chief Research Advisor
- Dr. Slava Gerovitch, PRIMES Program Director
- Paige Bright and Mary Stelow, PRIMES Circle coordinators

9:45-10:45 am: Session 1: PRIMES Circle

- Arjun Kaushik and Alyssa Yasuhara, "Surfaces in Knot Theory" (mentor Sabine Chu)
- Yoojung Esther Choe, Maya Figelman, and Alicia Pité, "From Naive Comprehension to ZFC" (mentor Diego Gonzalez Gauss)
- Corrine Chen and Justine Lai, "A Tennis Paradox" (mentor Jenny Jin)
- Bella Chen, Ziyao Ma, and Alice Yin, "Introduction to Sylow's Theorem" (mentor Maximus Lu)

11:00-12:00 pm: Session 2: PRIMES Circle

- Quan Le and Huy Tran, "Beyond Counting: The Deeper Meaning of Combinatorics" (mentor Julia Kozak)
- Mogos Chile and Youssef Mohammed, "Transformations in Geometry" (mentor Ezra Guerrero)
- Nang Dang and Timothy Woods, "The Kelly Criterion in the Modern Day" (mentors Lilian Zhu)
- Jaedon Ruan and Brian Xu, "How to (Potentially) Win a Million Dollars: An Introduction to the Riemann Zeta Function" (mentor Allen Lin)

1:00-1:40 pm: Session 3: PRIMES STEP

- Chris Chen, Vivian Chen, Ray Cui, Ermin Dong, Alexander Radul, Lev Radul, Jack Shan, Arthur Shu, Kenneth Sun, Kenneth Wood, William Zelevinsky, and Brian Zhao, "Down the Rabbit Hole of Vouchers" (mentor Dr. Tanya Khovanova)
- Siyona Agarwal, Julian Bernhoft, Yonis Gulleth, Eric Huang, Gill Karam, Benjamin Li, Brandon Ni, Soham Samanta, Leone Seidel, and Boya Yun, "Self-Referential and Immensely Questionable Tests" (mentor Dr. Tanya Khovanova)

2:00-3:00 pm: Session 4: PRIMES Circle

- Chloe Carrano and Eileen Lee, "Introduction to Graph Theory: Trees and Colorings " (mentor Nathra Ramrajvel)
- Daniel Gladstone and Isaac Goodman, "A Visual Exploration of Dynamical Systems in the Complex Plane " (mentor Mikaela Finlay)
- Cathen Fontanilla and Zoe Guo, Rohan Garg, and Benny Wang, "An Introduction to Graph Algorithms " (mentor Rosa Paten)
- Emily Chen, Arya Nayak, and Hazel Thrasher, "Automata Theory: How Machines Hear and Recognize Speech " (mentor Alicia Lin)

3:15-4:00 pm: Session 5: PRIMES Circle

- Jonathan Hanna, William Koyfman, and Sam Mayle, "Trees and Paths in Graph Theory " (mentor Dyne Lee)
- Gina Li and Joshua Park, "Coxeter Groups " (mentor Lillian MacArthur)
- Michelle Lau and Kaylee Xie, "Skeletal Structures, Molecules, and Origami Design " (mentors Sam Packman)

2026 PRIMES SPRING-TERM CONFERENCE ABSTRACTS

SUNDAY, MAY 17

SESSION 1. PRIMES CIRCLE

Arjun Kaushik & Alyssa Yasuhara

Surfaces in Knot Theory

Mentor: Sabine Chu

This project studies the significance of surfaces in knot theory, and focuses on representations of knots in surfaces and Seifert surfaces. The presentation is set up in three parts: an introduction to knots, followed by a definition of surfaces and their characteristics, and finally, properties of Seifert surfaces. Lastly we discuss genus, orientability, compressibility, and the concept of the Euler characteristic, which all act as invariants for our surfaces, and we introduce Seifert surfaces as orientable surfaces that are related to knots and links.

Yoojung Esther Choe, Maya Figelman, & Alicia Pité

From Naive Comprehension to ZFC

Mentor: Diego Gonzalez Gauss

The notion of set theory started with the work of George Cantor in the 1870s and 1880s, referred to as naive set theory. The foundations of naive set theory implied paradoxes like Cantor's paradox, Russell's paradox, and the Burali-Forti paradox, inspiring mathematicians to axiomatize set theory. We consider how this "foundational crisis" was resolved by inspecting Zermelo-Fraenkel with choice (ZFC), a classic axiomatic system that has become the basis for modern set theory.

Corrine Chen & Justine Lai

A Tennis Paradox

Mentor: Jenny Jin

This presentation explores the surprising result that someone loses a tennis match despite winning more points. Using binomial random variables and Markov transition matrices, we modeled the probabilities of winning individual games in all scoring scenarios. These results were then applied to the possibilities of the phenomenon within an entire tennis set.

Bella Chen, Ziyao Ma, & Alice Yin

Introduction to Sylow's Theorem

Mentor: Maximus Lu

This presentation introduces the fundamental concepts of group theory, a branch of abstract algebra motivated by the study of symmetry. We begin by defining a group and providing basic examples using number systems and modulo arithmetic. Next, we introduce subgroups and normal subgroups, which are subsets of groups that allow us to form quotient groups and kernels. Building upon these ideas, we define group actions and the specific action of conjugation. This allows us to build toward Sylow's Theorem, which deals with the existence and properties of subgroups with a prime power order. We conclude by discussing the applications of Sylow's Theorem in studying the structure of finite groups.

Quan Le & Huy Tran

Beyond Counting: The Deeper Meaning of Combinatorics

Mentor: Julia Kozak

Combinatorics is often introduced as the mathematics of counting, but its deeper purpose is to uncover hidden structure within complex systems. Rather than simply asking how many possibilities exist, combinatorics studies how choices, arrangements, and patterns interact to create order from seemingly chaotic situations. In this presentation, we discuss permutations and combinations, probability, the Binomial Theorem, and Pascal's Triangle, showing that combinatorics is not only about counting outcomes, but also about understanding the structure behind them.

Mogos Chile & Youssef Mohammed

Transformations in Geometry

Mentor: Ezra Guerrero

In this presentation, we will cover functions, transformations, and relate them to linear algebra. For functions and transformations, we will delve into the definitions and characteristics as well as applications. Regarding linear algebra, we will introduce matrices and vectors, demonstrating how we can utilize these tools in transformational geometry. Overall, we will focus on the importance of these topics in the study of geometry.

Nang Dang & Timothy Woods

The Kelly Criterion in the Modern Day

Mentor: Lilian Zhu

This presentation describes the mathematical context of the Kelly Criterion to explain its importance in modern optimization. It is meant to provide a base of knowledge for which a reader can become educated on the subject and thus grant the casual reader the means to understand and the interested learner the foundation of study to participate in the development of applications of the Criterion.

Jaedon Ruan & Brian Xu

How to (Potentially) Win a Million Dollars: An Introduction to the Riemann Zeta Function

Mentor: Allen Lin

The Riemann Hypothesis, which stems from the Riemann zeta function, is one of seven Millennium Problems from the Clay Institute, with a one million dollar prize. It is especially important because of its relationship with prime numbers, potentially revealing much about the distribution of primes. We created an expository explanation of $\zeta(s)$ meant for a general audience while still including proofs and important number theory techniques. We first introduce techniques such as Gamma functions, Bernoulli numbers, and polynomials. We then discuss the proof for computing $\zeta(s)$ for even numbers using Euler's technique, focusing specifically on proving $\zeta(2) = \frac{\pi^2}{6}$. Finally, we introduce the Riemann Hypothesis and links to the Prime Number Theorem. This presentation provides listeners with full proofs of the Riemann zeta function and its relationship to primes beginning from definitions in an easy-to-follow manner.

SESSION 3. PRIMES STEP

Chris Chen, Vivian Chen, Ray Cui, Ermin Dong, Alexander Radul, Lev Radul, Jack Shan, Arthur Shu, Kenneth Sun, Kenneth Wood, William Zelevinsky, & Brian Zhao

Down the Rabbit Hole of Vouchers

Mentor: Dr. Tanya Khovanova

Saving money or splurging? The Self-Referential Store welcomes you to the world of vouchers. However, price tags on vouchers are deceptive, and what you pay depends on the order in which you buy the vouchers. The key rule: the cost of each voucher is the product of its price tag and the price tag of the previous one. In addition to this weird cost for a set of vouchers, we introduce the pairwise cost and loop cost. We derive formulas to determine the best way to save or waste money across these three pricing systems and prove that the strategies rely only on the relative order of the price tags. But beware: even a slight alteration in the order you buy your vouchers could make or break your savings.

Siyona Agarwal, Julian Bernhoft, Yonis Gulleth, Eric Huang, Gill Karam, Benjamin Li, Brandon Ni, Soham Samanta, Leone Seidel, & Boya Yun

Self-Referential and Immensely Questionable Tests

Mentor: Dr. Tanya Khovanova

Think you're smart? Come test your intelligence using our Immensely Questionable tests (IQ tests). Here is a sample question.

If you choose the answer to this question at random, what is the probability you will be correct?

A: 25%, B: 50%, C: 60%, D: 25%

Can you find the correct answer? In our presentation, we explore the mathematics behind these illogical logic puzzles.

SESSION 4. PRIMES CIRCLE

Chloe Carrano & Eileen Lee

Introduction to Graph Theory: Trees and Colorings

Mentor: Nathra Ramrajvel

Graph theory analyzes the relationships between a graph's vertices and edges and is often used as a systematic framework for modeling systems. In this talk, we discuss two types of graphs that are structured and defined by particular restrictions: tree graphs and colored graphs. We begin with trees, highlighting how their hierarchical structures have applications to computer science within Huffman coding and heap-based priority management. From modeling social media connections to storing data in a ranked, systematic way, tree graphs have a wide variety of applications in the real world. Then, we explore graph colorings, focusing on how they behave in different classes of graphs. We then turn to Ramsey theory, where we show that sufficiently large graphs must contain highly structured subgraphs no matter how their edges are arranged or colored. We apply these ideas to real-life settings, including biological networks.

Daniel Gladstone & Isaac Goodman

A Visual Exploration of Dynamical Systems in the Complex Plane

Mentor: Mikaela Finlay

In this talk, we will introduce the concept of dynamical systems and ways to visualize them in the complex plane. We will work specifically with the quadratic map, $Q_c(z) = z^2 + c$, and build an understanding of its dynamics for various values of c . By the end of this talk, we will understand the famous Mandelbrot set and its relationship to Q_c .

Cathen Fontanilla & Zoe Guo

An Introduction to Graph Algorithms

Mentor: Rosa Paten

In this presentation, we explore the basics of graph theory by beginning with a short background section on graph theory fundamentals and properties of graphs, and connecting these properties to combinatorial algorithms to find special traits, like the shortest path between two points. In particular, we will be covering the Gale–Shapley Algorithm, Kruskal’s (Greedy) Algorithm, and Dijkstra’s Algorithm, and will discuss what these algorithms look like in practice. Finally, we will apply algorithms to real-life scenarios, demonstrating how combinatorics can help us gain a better understanding of our world.

Emily Chen, Arya Nayak, & Hazel Thrasher

Automata Theory: How Machines Hear and Recognize Speech

Mentor: Alicia Lin

The theory of computation provides the framework for understanding how computers and machines process information and solve problems. This presentation explores the fundamental concept of automata theory and its connection to real-world speech detection systems. To establish our comprehension of finite automata and regular languages, we present formal definitions and state diagrams. We further investigate automata theory with context-free grammars and pushdown automata, utilizing computational power to illustrate recursive patterns of languages. The relationship between pushdown automata and context-free grammars is significant in understanding how different computational models relate to each other. The link between automata theory and practical applications such as speech recognition demonstrates how simple computational models form the foundation for valuable real-world innovations.

SESSION 5. PRIMES CIRCLE

Jonathan Hanna, William Koyfman, & Sam Mayle

Trees and Paths in Graph Theory

Mentor: Dyne Lee

Graph theory is an important field of modern-day mathematics originating in the 18th century. We will focus mainly on trees, a special class of graphs. Trees are useful because they give the simplest way to connect a set of nodes, which makes them important in studying networks, paths, and optimization problems. We will introduce the basic terminology of graph theory, prove several fundamental properties of trees, and provide visual proofs and examples. Finally, we will discuss some pathing algorithms to show how graph theory can solve concrete problems.

Gina Li & Joshua Park

Coxeter Groups

Mentor: Lillian MacArthur

Group theory is a branch of abstract algebra that studies the structure and properties of objects called groups. We will focus on a special type of group — the Coxeter groups. We will first define generators and relations and use them to define Coxeter groups. Then, we will show how diagrams can represent Coxeter groups, explore their connection with symmetry and reflections, and present the finite Coxeter groups.

Michelle Lau & Kaylee Xie

Skeletal Structures, Molecules, and Origami Design

Mentor: Sam Packman

This presentation explores how to determine origami templates through the derivation of skeletal structures and molecules. This topic also explores the fold and 1-cut theorem and how their patterns are connected to skeletal structures. By designing the origami templates through this method, uniaxial bases can be constructed to demonstrate how all the lines can coincide, as well as the ability for the origami template to fold flat. Another way to derive skeletal structures is to combine multiple “molecules”. These molecules are basic origami skeletons, each with its own unique properties, that are derived from characteristic lines of tangent circles. As a result, these diagrams highlight the connection between origami and math, showing how mathematical principles can be used to determine the makeup of origami structures.