Luis Modes

✉ modes@mit.edu • 🌐 luismodes.com • 📱 +1 (617) 852-1657

"Being happy is the greatest form of success." – unknown

Research Interests

Algebraic geometry, arithmetic geometry, and topology

Profile

Languages: English (fluent), Spanish (native), and Japanese (intermediate)
Programming: Python, LaTeX, and SageMath
Skills: Problem-solving, math olympiad coaching, and mentoring

Education

Massachusetts Institute of Technology — Cambridge, MA
Undergraduate — *September 2021 – Present*

Academia Interamericana de Panamá sede Cerro Viento — Panama, Panama
High School Diploma — *March 2008 – December 2020*

Selected Honors and Awards

Hartley Rogers Jr. Prize for the best project of the MIT Math Department's Summer Program in Undergraduate Research (SPUR) — August 2024

International Mathematical Olympiad (IMO): Bronze Medal — July 2021

International Mathematical Olympiad (IMO): Bronze Medal — September 2020

Panamanian Mathematical Olympiad: Gold Medal, rank 1st in 2019 and 2020 — 2016 – 2020

Asian Pacific Mathematical Olympiad (APMO): Silver Medal — 2019

Research Experience

Summer Program in Undergraduate Research (SPUR) — MIT 2024 - Present

- Generalized a theorem that identifies the spherical Hall algebra of $\overline{\mathrm{Spec}(\mathbb{Z})}$ with a shuffle algebra to a theorem about the spherical Hall algebra of $\overline{\mathrm{Spec}(\mathcal{O}_K)}$, where K is a number field with class number 1 and $\mathcal{O}_K$ is its ring of integers. Currently working on generalizing this theorem to any number field K through the Undergraduate Research Opportunities Program (UROP). Our paper can be found here: arXiv:2411.17055: The spherical Hall algebra of $\overline{\mathrm{Spec}(\mathcal{O}_K)}$.
  Reference: Zhiwei Yun

18.821 Project Laboratory in Mathematics — MIT 2024

- Worked with a group on two guided research problems. Wrote a paper and gave a presentation for each of them. The first problem was about exploring the density of integer solutions to the diophantine equation $x^3 + y^3 = z^3 + w^3$. The second problem was about exploring the density and existence of *happy sequences*: sequences of zeroes and ones invariant under replacing 0 with 10 and 1 with 100.
  Reference: Roman Bezrukavnikov

Directed Readings and Programs

Directed Reading Program MIT 2023-2024

- Read and made a presentation about h-cobordisms and Smale's theorem.
  Reference: Joye Chen
- Read and made a presentation about *Using the Borsuk-Ulam Theorem* by Jiří Matoušek.
  Reference: Elia Portnoy

Preliminary Arizona Winter School MIT 2023-2024

- Watched recorded lectures and worked on problem sets with a TA for 9 weeks. The topics were elliptic curves with complex multiplication in 2023 and local fields in 2024.
  References: Ju-Lee Kim and Bjorn Poonen

18.099 Independent Study: Low-dimensional topology MIT 2024

- Read *Knots and Links* by Dale Rolfsen.
  Reference: Joshua Wang

18.099 Independent Study: The geometry of complex analysis MIT 2023

- Read *An Introduction to the Theory of Analytic Functions of One Complex Variable* by Lars Ahlfors.
  Reference: Joshua Wang

Presentations

Isomorphism between Hall algebra and shuffle algebra	MIT 2024
Happy sequences	MIT 2024
Sums of cubes	MIT 2024
The h-cobordism theorem	MIT 2024
Heegard Splittings	MIT 2023
Applications of the Borsuk-Ulam Theorem	MIT 2023

Volunteer Roles, Teaching, and Coaching

HMMT Problem Czar August 2022 – May 2023

- Wrote and chose problems for the February tournament and helped with the November tournament.

Panamanian Mathematical Olympiad Member January 2021 – Present

- Wrote a handout and gave a lecture about Circle Geometry in a seminar for high school teachers.
- Organized the shortlist of proposed problems for the 2021 and 2022 Panamanian Mathematical Olympiad.
  Reference: Pedro Marrone

Panamanian Training Program Instructor October 2020 – Present

- Served as Panama's Leader at the 2024 Iberoamerican Mathematical Olympiad.
- Served as Panama's Deputy Leader at the 2023 International Mathematical Olympiad.
- Currently serve as a math olympiad instructor, mainly in Geometry and Algebra.
- Gave the new students an introductory LaTeX course.
- Served as Panama's Deputy Leader at the 2020 Iberoamerican Mathematical Olympiad.
- Served as a jury member at the 2020 Central American and Caribbean Mathematical Olympiad.
  Reference: Pedro Marrone

AIPCV Math Olympiad Coach April 2018 – December 2020

- Trained the AIPCV school's team for the first and second rounds of the National Olympiad.
- Wrote a virtual book to train the team.

Work Experience

MIT PRIMES Circle Mentor MIT, 2023-2024

- Mentored high school students through the material of *The Knot Book* by Colin Adams in 2023 and *Thinking Geometrically: A Survey of Geometries* by Thomas Q. Sibley in 2024.
  Reference: Marisa Gaetz and Mary Stelow

Undergraduate Assistant for 18.901 Introduction to Topology MIT, 2023

- Graded homework, midterms, and the final exam. Wrote solutions and held office hours.

Undergraduate Math Association Mentor MIT, 2022

- Provided mentorship to students in introductory real analysis and algebra classes.

Grader for 18.101 Analysis and Manifolds MIT, 2023

- Graded homework.

Grader for 18.100B Real Analysis MIT, 2022

- Graded homework and wrote solutions.

Selected Coursework

Algebra

- 18.725 Algebraic Geometry I
- 18.721 Introduction to Algebraic Geometry
- 18.705 Commutative Algebra
- 18.701 Algebra I and 18.702 Algebra II

Topology

- 18.905 Algebraic Topology I and 18.906 Algebraic Topology II
- 18.904 Seminar in Topology
- 18.901 Introduction to Topology

Number Theory

- 18.785 Number Theory I and 18.786 Number Theory II
- 18.783 Elliptic Curves
- 18.782 Introduction to Arithmetic Geometry

Analysis

- 18.101 Analysis and Manifolds
- 18.100B Real Analysis

Programming

- 6.100B Introduction to Computational Thinking and Data Science
- 6.100A Introduction to Computer Science and Programming in Python

Physics

- 8.01 Physics I and 8.02 Physics II