NEWSLETTER

MATHEMATICS

Harvard University Department of Mathematics

Academic Year 2022-2023

DEPARTMENT OF MATHEMATICS
HARVARD UNIVERSITY

Table of Contents

Message From the Chair

Michael J. Hopkins

George Putnam Professor of Pure and Applied Mathematics

Mathematics Department Chair

Dear Friends,

This past year has represented a complete return to our campus events. Our classrooms and seminars have been lively, and our very popular afternoon tea and Friday wine and cheese events are back in full swing.

We hosted the performance of a play about the life of Emmy Noether and held the first annual "Jameel Al-Aidroos Mathematical Pedagogy Lecture Series."

We also hosted two in-person international events. The conference "The Circle at infinity" in honor of Curt McMullen was held last summer, and our annual "Current Developments in Mathematics" conference was held in April.

This past year, several of our faculty members were honored for their work. Barry Mazur was awarded the Chern Medal, Melanie Matchett Wood received a MacArthur Fellowship, Peter Kronheimer was awarded (jointly with Tomasz Mrowka) the Steele Prize for Seminal Contribution to Research, and Mark Kisin was elected to the American Academy of Arts and Sciences.

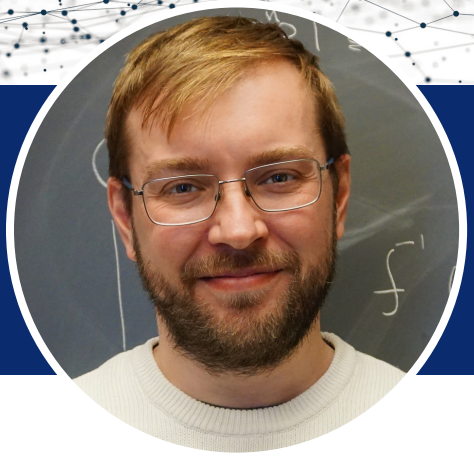
We said goodbye to 11 of our graduate students who received their PhDs, and welcomed 12 new students. We also said goodbye to 7 departing Benjamin Peirce (BP) Fellows and welcomed 5 new BPs, 3 postdocs, and 2 Junior Fellows.

In the pages that follow you can find profiles of several members of our community, and pieces highlighting the accomplishments of others. I hope you enjoy reading about some of the wonderful things that happened over this past year.

With Best Wishes,

Mike Hopkins

Message From the Director of Undergraduate Studies



Dusty Grundmeier

Associate Senior Lecturer

Assistant to the Director of Undergraduate Studies

Dear Friends,

Looking back on the last year in the undergraduate program, we are so proud of our students and all the incredible work they have accomplished. We welcomed 98 new math concentrators this year. The overall number of undergraduate concentrators is now 277 students, up from 226 just four years ago. We're excited to see so many students in our courses and discussing math in the common room.

We have also been hard at work developing new courses and programs for our students. Philip Matchett Wood created the new course "Introduction to Formal Verification of Mathematics." Students worked in the programming language Lean to formally verify mathematical results. Over the last few years, we've also developed the Directed Reading Program (DRP) in the department. The program pairs undergraduates with graduate student mentors for semester-long reading projects in math. A key goal of the program is to welcome students from a wide range of backgrounds and interests. Our graduate students have done an incredible job mentoring and encouraging our undergraduates in their passion for mathematics. The program supported more than 50 projects this year, and we hope to continue it next year as well.

This summer, we are starting a new summer research program for undergraduates. Philip Matchett Wood and John Cain are leading two undergraduate research groups on problems in graph theory and combinatorial game theory. Many of our students are participating in research experiences for undergraduate (REU) programs across the country. We're eager to hear about all our students' projects and internships when they return to campus in the fall.

Finally, we want to congratulate all of our graduating students and our senior thesis writers. We had 16 thesis writers this semester, and they all did outstanding scholarly work. We hope all our graduating students stay in touch and share what mathematical adventures come next.

With Best Wishes,

Dusty Grundmeier

Photo courtesy of Ryan H. Doan-Nguyen.

Madison Shirazi

‘23, Mathematics & Physics Friends Prize Recipient

When and how did you discover your love for mathematics?

I’ve been doing math since before I can remember but I got more involved with it in middle school. I had a math teacher who also taught older grades, and she gave me those lessons to work on in class. I wasn’t a big fan of competition math, but I loved proofs, studying new math and thinking abstractly about concepts: that was the part of math that really drew me in. I love art—I like to paint, and my grandmother taught me to sew—so I really like the visual parts of math and trying to picture abstract mathematical objects.

How did math become your concentration?

My high school allowed me to take math classes at a local college, so I knew I liked college math. Coming into Harvard, I knew I wanted to study math, but I also wanted to make sure I wasn’t missing out on anything else. During my first and second year, I branched out and took a lot of random classes in different departments. The fact that math still stood out as an interest while I was exploring all these other fields convinced me that I wasn’t so committed to math that I was forgetting about other options.

What brought you to Harvard? What has your time here and with the math department been like?

I was looking at different course catalogs and comparing the math courses. That was my very scientific measure. I’m from New York City so I knew I wanted to be in a city, but I really wanted a school with math class titles and descriptions that interested me. I applied early and that was it! Now, every semester that I look at the course catalog it’s just like when I was exploring colleges: I can always find classes that I’m excited about. I may not know what all the words in the titles and descriptions mean, but I know I’m going to find out!

Because I just took a random math class in the fall of my first year, I didn’t have the community a lot of people find in the intro sequences with other same-year math concentrators. But through pset partners and CAs, I think I really did find a lot of friends in the math department. A lot of my closest friends now are people that I psetted with or from Harvard Undergraduate Gender Inclusivity in Mathematics (HUGIIM), which I’m a part of. I really love the instructors, too. There are a lot of Benjamin Peirce Fellows (BPFs) who teach classes and they’re really amazing. They’re younger so they have a good idea about what it’s like to be a math college student right now.

Tell me about your senior thesis, “Finding Balance in Chaos: Approximating orthogonal polynomials on Julia sets.”

I knew I wanted to do a thesis in analysis and I’m working with Professor Laura DeMarco, who studies a lot of dynamics, so I ended up with a thesis in potential theory. The motivating problem is, you start with a shape in two dimensions and imagine that it’s made of conducting metal. If you add a positive charge to the piece of metal, where does the charge go? Everything in physics tends to an equilibrium state, so what is the equilibrium state of the charge on the shape? Turns out, these equilibrium states exist and are unique. There’s a pretty good description of them for certain shapes: surprisingly, for Julia sets, which are a type of fractal, the equilibrium states are really easy to approximate.

I studied and compared different ways to visualize and approximate this equilibrium charge. I also worked on orthogonal polynomials: people defined a sequence of polynomials on these Julia sets and

it turns out that sometimes these zeroes of these polynomials can approximate the equilibrium charge distribution of the Julia set. The connection between the orthogonal polynomials and the Julia sets was really surprising to me!

What does the Friends Prize and the talk you will give as part of receiving it mean to you?

I had spent so many hours on this thesis and to see that someone had actually read it was so exciting. It's great that my work is being seen and that I get to present it to people who may not be actively studying math right now. I believe in making math accessible to everyone. The theoretical physicist Richard Feynman believes that you only really know a topic when you can explain it to someone not familiar with your field. The talk will be a test to see how much of my thesis I can communicate! I've been using my siblings as guinea pigs: if they can understand it, hopefully everyone else can, as well.

How did you grow as a mathematician while at Harvard and where do you see yourself in the future?

First-year me really wanted to teach math to middle schoolers. I loved my math teachers growing up and middle school is a great age since you're getting old enough to be more rigorously exposed to exciting math topics. Second- and third-year me wanted to go to grad school. Now I'm planning on taking a few years away from school. I'll be working in finance and volunteering for the New York Math Circle where I'll be teaching middle schoolers. I decided to take the break to make sure grad school is the right decision for me: I don't want to jump in and commit five years to getting a Ph.D. just because it seems like the natural next step.

Benjy Firester

'23, Mathematics
Friends Prize Recipient

When and how did you discover your love for mathematics?

My dad studied math in college and he taught me things like abstract algebra and modular arithmetic from a young age. I already loved math in high school, but I also gravitated towards computer science and physics. I think I did more math than anything else, because at my high school, Hunter College High School, I had opportunities to take additional math classes at the college associated with it, Hunter College. I came to Harvard with an open mind, but I knew I really enjoyed math-related disciplines.

How did math become your concentration?

Here, I was drawn to various math classes. Soon, I was taking and enjoying mostly math courses. It helped that I had good classes and excellent teachers like Joe Harris. My first two years, I took a lot of geometry classes from amazing teachers like Sébastien Picard and Valentino Tosatti who developed my love of the field. It so happened that the professors who taught me my first year taught very interesting continuation courses in my second year. I continued to study a lot of differential geometry and decided to pursue this field in graduate school.

What brought you to Harvard? What has your time here and with the math department been like?

My sister was at Harvard so I visited a lot, but I really came here for the math department. When I spoke to professors and students about math, it seemed like they were all pointing towards Harvard and, in the end, I made my decision based on those conversations. I decided that if I wanted to really go into math, Harvard would be the place with the most opportunities. I'm sad to leave. I'm really excited about where I'm going, but I have loved every single moment here, from my first-year courses to my recent topics courses. I met my best friends in class my first year, and Harvard has indeed given me every opportunity for which I could have hoped.

Tell me about your senior thesis, "Mostow rigidity and hyperbolic 3-manifolds."

About a year ago, I was thinking about the kinds of things I wanted to study for my senior thesis. I was interested in low-dimensional geometry. There's this beautiful, extremely difficult result called the geometrization theorem. To actually learn the tools to understand this theorem requires many more years of math which I hope to do. Curt McMullen, my thesis advisor, suggested I look at this one particular piece; the hyperbolic case for 3-manifolds. I'm very thankful for his mentorship and teaching, starting in my second year.

What I learned is that hyperbolic 3-manifolds are the most important objects in three-dimensional geometry. Most three-dimensional geometry is hyperbolic, so understanding these objects is really critical to understanding geometrization in three dimensions. Hyperbolic manifolds are characterized by having constant negative sectional curvature, which means they bend away from each other in different directions, like a Pringle chip. The Mostow rigidity theorem states that in three dimensions or higher, any hyperbolic structure on a manifold is unique, which fails in the lower dimensions. This allows us to categorize hyperbolic 3-manifolds.

This provides a powerful link between geometry and topology, because it gives a unique or canonical geometry on these topological spaces. And geometry imposes a lot of structure, which gives you a lot of tools and theorems, but it's very rare to find these in a way that directly links to topology. Hyperbolic geometry is a really beautiful setting where you can identically link the geometry and the topology. The geometrization theorem actually tells you that not only is this a space where the geometry equals the topology, but it's actually an extremely rich and important one. It's a really essential field and I'm glad I spent so much time devoted to it.

What does the Friends Prize and the talk you will give as part of receiving it mean to you?

One of my friends got the Friends Prize last year and we were all very proud. She was very excited to give the talk and it was indeed a great experience. The fact that some great people have received this prize was also in the back of my mind. I am extremely honored and happy to have been chosen this year, and I look forward to sharing my work at the talk.

How did you grow as a mathematician while at Harvard and where do you see yourself in the future?

One of many special things about Harvard's math department is how you get a taste of what mathematics looks like very early on. Even though it's impossible to learn it all, I think you quickly develop an understanding of its scope and how people approach it. You learn the words before you know how to use them, and that helps you explore on your own and find topics that interest you. I'm going to be studying differential geometry in a Ph.D. program at MIT. I'm really excited about that.

Laura DeMarco

Professor of Mathematics

Laura DeMarco first joined our community as a Ph.D. student in 1998. After graduating in 2002, she taught at the University of Chicago, the University of Illinois in Chicago, and Northwestern University. DeMarco returned to Massachusetts to become a Harvard Professor of Mathematics in 2020. Over the years, her work has been awarded by the American Institute of Mathematics, the Sloan Foundation, the Simons Foundation, and the American Mathematical Society, and she is an elected member of the National Academy of Sciences.

Discovering Mathematics

Before research and mathematics, teaching was DeMarco's passion. She only discovered that math was something she could research in her second year as an undergraduate student at the University of Virginia. "I was taking a course with a law professor on social science theory," DeMarco recalled. "And he was the one who explained to us that all our professors are doing research, even in mathematics. It opened a door for me to recognize that hey, this is an option! I really liked math and I could continue doing it forever!" DeMarco had started out as a physics major, but graduated with a B.A. in Mathematics and Physics.

She originally fell in love with complex analysis but discovered the field of dynamical systems as a first-year graduate student at the University of California, Berkeley. "I realized you could combine these two subjects," DeMarco said. "Complex analysis and dynamical systems were a good match. There is a field called complex dynamical systems, and that's held my attention since I came across it." These days, her research mainly focuses on the dynamics of holomorphic maps on algebraic varieties and their moduli spaces, studied with a combination of complex-analytic and algebraic techniques.

About Harvard

DeMarco transferred to Harvard as a graduate student because she wanted to work with Curtis McMullen, now Maria Moors Cabot Professor of the Natural Sciences. She was still in the process of exploring various mathematical subjects and McMullen's studies in the field of complex dynamics appealed to her. He became her thesis advisor and Harvard became the place where she received her Ph.D.

"Then I lived in Chicago for 18 years and I loved it, but when Harvard announced they had openings, I knew I wanted to apply to come back," she said. The familiar faces among the staff and faculty delighted DeMarco. "The whole experience has felt like coming back home, back to a community of people I feel raised me," she reflected. "Being a graduate student and learning to become an independent researcher was an important but difficult period in my life, and the community here was really supportive. Knowing a lot of the same people were here was wonderful."

In fact, she also met her now husband and fellow Harvard Professor of Mathematics Mihnea Popa while here as a student. "He was in his first year as a postdoc, while I was in my last year as a graduate student," DeMarco recalled.

Outside Mathematics

When not teaching or conducting her own research, DeMarco indulges in her love for classical music. "I used to be very serious about playing the flute," she said. As an undergraduate student, she played with various orchestras and spent one summer as the principal flutist for an opera company in Virginia. In Chicago, she joined a flute ensemble and performed at weddings, churches, and even a fashion show. "I don't play the flute anymore because it pains me not to do it at a professional level, but in exchange I took up piano lessons," DeMarco said. "It's something I can just enjoy, without having to be good at it or trying to prove myself to anybody." She's been taking piano lessons for the past eight years and is currently working on a Bach Partita.

Elden Elmanto

Benjamin Peirce Fellow

Elden Elmanto joined Harvard as a Benjamin Peirce Fellow (BPF) in 2019 after completing his graduate studies at Northwestern University. In 2020 he assisted fellow BPF Ana Balibanu to organize the "Open Neighborhood Seminar," a general-audience colloquium series for all members of the Harvard math community, including undergraduates at any level. That same year Elmanto received a Certificate of Teaching Excellence from the Harvard University Derek Bok Center for Teaching and Learning. He also helped organize a learning seminar dedicated to current hot topics in and around algebraic topology alongside George Putnam Professor of Pure and Applied Mathematics and Department Chair Michael Hopkins. In the fall of 2023, Elmanto will take up a position as assistant professor at the University of Toronto.

Discovering Mathematics

Elmanto's interest in mathematics didn't develop until college. Other than a passing curiosity in high school chemistry, he had always been more drawn to the humanities. "I was raised in Singapore, where math was more rote learning where you memorize a bunch of formulas," Elmanto recalled. "I didn't know there could be any kind of narrative to be produced from math, which I find to be the most beautiful thing about it." He didn't realize this until he took a class at the University of Chicago with Paul Sally, affectionately nicknamed the "Math Pirate" by his students because of his missing legs and eyepatch. "He made a community of mathematicians," Elmanto said. "He showed us that math was more than a bunch of random problems, that there's a story to be told."

In Chicago, Elmanto was exposed to the concept of a "writing down a proof" in mathematics, an idea he had only been peripherally exposed to in high school but to which he immediately felt drawn. "A proof is a story," he said. "It's a way to say infinitely many things using finitely many words. In order to do that, you need to tell a convincing, coherent story, a narrative which fits into the rest of mathematics at large." Thinking of math in those terms appealed to him immensely as he found it closer to parts of the humanities than the sciences.

About Harvard

In time, Elmanto's focus settled on the intersection of algebraic geometry and algebraic topology. He would borrow methods and ideas from algebraic topology, a way to study flexible spaces, and apply them to study algebraic geometry, a much more rigid field. He was drawn to Harvard partially because of Hopkins, who he considers a pioneer in his subject of interest. "I really wanted to work with him and learn from him," Elmanto said.

In the four years he has been at Harvard, Elmanto has come to develop what he calls motivic cohomology of singular schemes. Motivic cohomology is a way to study algebraic varieties first developed in the '80s and '90s. According to Elmanto, it was "kind of impossible to study motivic cohomology when spaces are pathological before our present decade, but we've finally developed enough math to do that." Most of his time at Harvard has been devoted to this study "I've really developed as a mathematician," Elmanto said of his time with our department. "I've really learned what it means to do math in a good way and how to talk to people about it both casually and formally."

Outside Mathematics

Bouldering, a form of free climbing performed on small rock formations or artificial rock walls without the use of ropes or harnesses, is a little-known but favored pastime for mathematicians. It's certainly one of Elmanto's favorite activities and he does it two to three times a week. He loves the spatial reasoning and problem-solving skills it involves. "I go bouldering with mathematicians all the time and we sometimes talk about math, and sometimes talk about life," he said. "It's a whole subculture within the subculture of math."

Message From the Director of Graduate Studies

Mark Kisin

Perkins Professor of Mathematics

Director of Graduate Studies

Dear Friends,

We are excited to report on the continued success of our graduate program. This year, we have 53 graduate students, including 28 students from 15 different countries, creating a diverse and dynamic community. Our graduate students engage in mathematical research, instruction, and learning, while enjoying a welcoming and supportive environment that fosters camaraderie through casual conversations over tea and cookies, and student-run seminars such as Trivial Notions.

In the fall, we welcomed 12 new students who demonstrated their knowledge of algebra, algebraic geometry, algebraic topology, differential geometry, real analysis, and complex analysis through the qualifying exam. Our first-year students participated in Math 300: Teaching Undergraduate Mathematics, preparing them for future roles as teaching fellows. Our graduate students have also taken leadership roles in organizing meetings for two affinity groups in the department: \mathbb{Q} outreach group supporting LGBTQIA+ individuals in the Department of Mathematics, and Real Representations, a monthly lunch group supporting underrepresented groups in mathematics open to everyone in the department. We are pleased to see growing attendance for both groups, reflecting our commitment to supporting underrepresented populations.

Throughout the past year, our graduate students have received funding from Harvard University, the Department of Mathematics, and organizations such as the National Science Foundation, the Natural Sciences and Engineering Research Council of Canada, and the Jack Kent Cooke Foundation. A particularly noteworthy contribution came from the Putnam family, which provided support to 17 students this year. This funding is vital to the success of our graduate program.

As we celebrate the achievements of our current students, we also congratulate our graduating students. These 11 students have produced original research in various mathematical subject areas and have secured successful placements in academia and industry around the country. We wish them the best as they embark on the next phase of their mathematical journey.

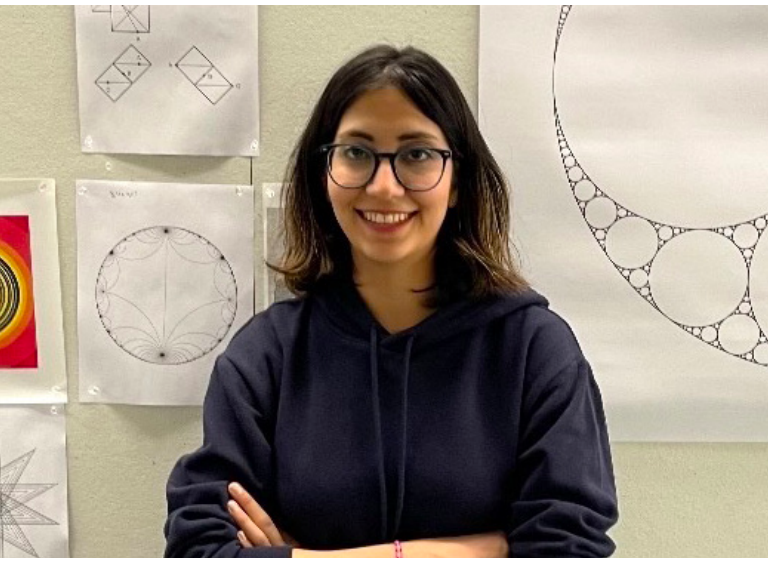
After 12 years as Director of Graduate Studies, I will be stepping down from my role at the end of this academic year. It has been a pleasure to serve in this capacity, and I am confident in the capable hands of my colleague, William Caspar Graustein Professor of Mathematics Melanie Matchett Wood, who will transition to Director of Graduate Studies in the coming year. As a faculty advisor, I look forward to continuing to work with graduate students and contribute to the success of the program.

With Best Wishes,

Mark Kisin

Graduate Student Spotlight

Tina Torkaman



Tina Torkaman is a '23 graduate of the Harvard University Department of Mathematics doctoral program. Following graduation, Torkaman plans to take on a three-year postdoctoral position at the University of Chicago as a Dickson Instructor.

As a child, Tina Torkaman loved math and art equally. She knew from a young age that one of those two passions would come to define her future, but it wasn't until she participated in a math olympiad in high school that she began to seriously consider mathematics. For a while, the competitive nature of olympiads was her driving motivation. However, the deeper she delved into the world of mathematics, the more she outgrew the ephemeral rush of competition.

By the time Torkaman began her undergraduate degree in mathematics at Sharif University of Technology in Tehran, she had found a new mathematical raison d'être, one that she would be able to carry with her long term.

"To me, art and math are very close in the sense that there is a creativity and beauty in both," Torkaman said. "Artists and mathematicians believe what they do is beautiful."

In time, however, she was able to articulate a difference in how she saw the two fields. The art and math she's most drawn to are both highly visual. Torkaman enjoys painting and sketching, and she loves low-dimensional geometry and topology. But what sets math apart from art for her is the objective truth at the core of math, the theorem that quietly exists and patiently waits for humans to discover it. "It feels almost magical when I learn a new theorem in number theory or when I solve a combinatorics problem," Torkaman said. "This hidden beauty and magic is what I like the most in mathematics."

She was considering applying abroad for her Ph.D., but wasn't planning to do so until after the end of her fourth year because she was concerned about her English proficiency. However, a visit to Harvard the summer before that led to a conversation with Perkins Professor of Mathematics Director of Graduate Studies Mark Kisin. "He assured me the most important thing was what I was doing with math and encouraged me to apply," Torkaman recalled. Spurred on by that conversation, she applied to a few of her top choice universities, Harvard among them. The decision changed her life.

"Harvard was new to me, but so was the whole city," Torkaman said. "Everything was new. I moved to

the U.S. when I was only 22 years old. I felt very confused about everything."

Thankfully, she quickly found a friend in her algebraic geometry class. "It was very helpful to me because we worked on problems together, studied together, got lunch together," she said. "Even just speaking with someone made me feel more confident in my English and more connected to this community."

Teaching was another key factor that helped her find her place at Harvard and the math community. In her second year, Torkaman taught Math 21a, "Multivariable Calculus." She'd had partial teaching experience, but that was the first time she was in a class as an instructor for the whole semester. She enjoyed it so much, she taught the class several more times. And every time she did, she received a Certificate of Distinction in Teaching from the Derek Bok Center for Teaching and Learning, an award based on an overall score of 4.50 or higher on the Q section evaluations.

As a mathematician, however, one of the most valuable things Torkaman found at Harvard was her research path. While she had taken a number of math courses as an undergraduate student, she entered her Ph.D. studies with no idea what kind of math she wanted to pursue. In her second semester, she came across hyperbolic surfaces in a reading group she'd formed with several fellow graduate students. Then she met her advisor, Maria Moors Cabot Professor of the Natural Sciences Curt McMullen.

He didn't push her in any particular direction and encouraged her to find something she really enjoyed. "I was very lucky that I found a great mentor like Curt," Torkaman said. "The Ph.D. journey is long and it has a lot of obstacles. And Curt has always been very patient, encouraging, and understanding, and that really helped me to stay motivated."

Torkaman's research interests now center around hyperbolic surfaces, geometry and dynamics of moduli space, ergodic theory, and hyperbolic 3-manifolds. "It took a long time to find the kind of math meant for me, but I'm very happy now," she said. "It's a great match."

Her thesis centers around studying closed geodesics by focusing on their intersection numbers. "I answer different questions," Torkaman said. "One is how long the intersection number might be in terms of length, another is about the equidistribution of the intersection points on the surface."

Her life at Harvard is not solely about math, however.

While she chose to dedicate the majority of her time to her passion for mathematics, art still holds a special place in Torkaman's heart. "Harvard has a nice, large clay studio," she said. "So for a year I attended clay classes. One was sculpting, another was wheel throwing." During the pandemic, she found online classes about the history of cinema in different countries like Japan and England. Sometimes, she'd pick the corner of a room to sketch, and sometimes she'd create short stories in comic strips.

Torkaman has also found a physical outlet in volleyball. "I've liked it since high school," she said. "It's helpful because it can be exercise and a social tool, and it reminds me of my time in high school and the friends I made there."

First-Year Graduate Students

Alejandro Epelde Blanco

Undergraduate Affiliation
University of Cambridge

Research Interests
My interests lie in geometry and low-dimensional topology. I'm currently looking at the construction of gauge theoretical invariants and their applications.

Alexandra Hoey

Undergraduate Affiliation
MIT

Research Interests
I am interested in number theory.

Matthew King

Undergraduate Affiliation
Stanford University

Research Interests
I am interested in arithmetic statistics, and I enjoy using methods from analysis and probability. Generally, I like algebraic and analytic number theory.

Dhilan Lahoti

Undergraduate Affiliation
Rice University

Research Interests
I'm interested in the intersection between algebraic geometry and algebraic topology.

First-Year Graduate Students

Isabel Longbottom

Undergraduate Affiliation
Australian National University

Research Interests
I am interested in algebraic topology, algebraic geometry, and homotopy theory. Currently I am thinking about algebraic K-theory.

Zhengkai Pan

Undergraduate Affiliation
Imperial College London

Research Interests
I'm interested in algebraic and differential geometry.

Dylan Pentland

Undergraduate Affiliation
MIT

Research Interests
I'm interested in p-adic geometry and p-adic Hodge theory.

Sina Saleh

Undergraduate Affiliation
University of British Columbia

Research Interests
My research interests are arithmetic and algebraic dynamics.

First-Year Graduate Students

Kush Singhal

Undergraduate Affiliation
University of Hong Kong

Research Interests
I am interested in algebraic number theory. Specifically, I am interested in the intersection of automorphic representation theory and arithmetic geometry.

Anda Tenie

Undergraduate Affiliation
Columbia University

Research Interests
I am interested in algebraic geometry with a focus on birational geometry and moduli spaces.

Victor Wang

Undergraduate Affiliation
University of British Columbia

Research Interests
I am primarily interested in algebraic combinatorics. I hope to better understand the wacky and wonderful world we live in through the study of mathematics.

Claudia Yao

Undergraduate Affiliation
University of Chicago

Research Interests
I am interested in gauge theory and geometric analysis. I am also interested in problems at the intersection of gauge theory and hyperbolic geometry. Currently, I am learning Seiberg-Witten theory and Ricci flow.

Graduating PhD Students

Maxim Jeffs

Advisor: Denis Auroux

Dissertation
A functional perspective on homological mirror symmetry for hypersurfaces

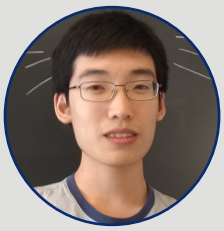
What's Next
Postdoc at Stony Brook University

Siyan Li-Huerta

Advisor: Mark Kisin

Dissertation
On the plectic conjecture

What's Next
NSF Postdoc Fellow at MIT



Kevin Lin

Advisor: Dennis Gaitsgory

Dissertation
Poincare series and miraculous duality

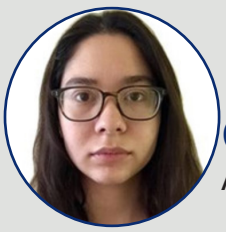
What's Next
Postdoc at University of Chicago, L.E. Dickson Instructor

Samuel Marks

Advisor: Mark Kisin

Dissertation
Prismatic F-crystals and Lubin-Tate (φq,Γ)-modules

What's Next
A position at the MIT Tegmark Group lab



Gwyneth Moreland

Advisor: Joe Harris

Dissertation
On the nef and effective cones of Hilbert schemes of points in projective space

What's Next
Research Asst. Professor, University of Illinois

Peter Park

Advisor: Joe Henrich (HEB)

Dissertation
The evolution of human cognition

What's Next
Postdoc fellowship, details to follow

Graduating PhD Students

Tina Torkaman

Advisor: Curtis McMullen

Dissertation
Geodesic currents on hyperbolic surfaces: Entropy, intersection number, and equidistribution

What's Next
Postdoc at University of Chicago, L.E. Dickson Instructor

Charles Wang

Advisor: Lauren Williams

Dissertation
Cluster algebras and mirror symmetry for homogeneous spaces

What's Next
Asst. Professor, University of Michigan

Joshua Wang

Advisor: Peter Kronheimer

Dissertation
The Cosmetic Crossing Conjecture for Split Links

What's Next
NSF Postdoc Fellow at MIT

Kai Xu

Advisor: Shing-Tung Yau

Dissertation
Moduli of vector bundles on curve and semiorthogonal decomposition

What's Next
Postdoc at CMSA & Physics

Lucy Yang

Advisor: Michael Hopkins

Dissertation
Categorical dynamics on stable module categories

What's Next
Ritt Asst. Professorship at Columbia University

Faculty Spotlight: Robin Gottlieb

Professor of the Practice in Teaching of Mathematics

Robin Gottlieb and son Amani, traveling through Peru.

For over 40 years Robin Gottlieb has been a champion of diversity in STEM, a supporter of graduate student development around teaching, and a proponent of pedagogical advancement at Harvard and the Department of Mathematics. She has taught and coordinated introductory mathematics courses, worked with the university's Derek Bok Center for Teaching & Learning, developed our department's preceptor program as an innovative, entrepreneurial group of teaching-focused faculty, and established and directed the Emerging Scholars Program to support the potential of first-generation students, students from under-resourced high schools, and those underrepresented in STEM fields.

Gottlieb's relationship with mathematics and pedagogy is in many ways inspired by her own non-linear journey as a student and the math teachers she encountered. The single bright spot in her math education through middle school was her fourth-grade teacher, who was an advocate of New Math. New Math was a unique teaching approach briefly used in the United States during the '60s that stressed abstract reasoning and conceptual understanding of the principles of mathematics, and de-emphasized technical computing skills. New Math didn't last long, but its core principles resonated deeply with young Gottlieb. "We were taught very abstractly and creatively with art, experiments, symbols, and the creation of our own math systems," she recalled. "I loved math in fourth grade and still remember it clearly." However, the creative side of math disappeared in future classes and while geometry piqued her interest, it wasn't until college that her passion was truly reignited.

As a first-year student at Brown University, she took a course with William Fulton. Fulton liked to sprinkle the course with a generous collection of optional extension problems and happily engaged in written "conversations" with Gottlieb as she attempted to solve them. "He would actually read what I wrote and write back," she marveled. "Now that I'm a teacher, I have no idea how he found the time to do this, but we'd go back and forth and I really enjoyed that." By the end of that class Fulton was familiar enough with the kind of problems she enjoyed and her specific style of mathematical thinking, and advised her to take an inquiry-based course with Thomas Banchoff. "That was when I decided, this is what I'm going to study," Gottlieb said.

She considered going to East Asia after graduating college to teach English in Japan or join the Peace Corps, but a visit to a highschool friend at Bennington College in Vermont derailed that plan. Before she knew it, Gottlieb had accepted a yearlong teaching position. "I enjoyed working with other people and getting them excited about the way things make sense," she said. "I realized that I like teaching, but I really needed to know more math." After the year was up, she went back to Brown for graduate school.

Following a personal tragedy in the winter of 1980, Gottlieb found herself adrift, looking for a distraction. She took a train to Boston thinking she'd visit with

a friend from graduate school who was a Benjamin Peirce Fellow at Harvard. In something of a trend, Gottlieb instead wound up applying to teach a course that no longer exists at the Harvard Department of Mathematics. In this case, however, the one year she'd originally planned for kept getting extended.

Forty years ago, when she wandered up from Providence, graduate students who taught calculus courses were left to their own devices. They were given an assignment and textbook at the beginning of a semester and set out on their own, without much coordination of orientation, just as Gottlieb herself had been launched as a graduate student. Sometimes this worked, and sometimes it did not. In the latter cases, complaints arrived at the department chair's door. David Mumford, the Department of Mathematics Chair at the time, got Gottlieb involved in thinking about how to better support graduate student teachers. As his chairmanship ended, he converted her "vagabond teacher" position into a preceptor position.

"I was here thinking about teaching and the student experience, when a lot of people here were thinking mainly about their research," she said. That was the key to finding her purpose. Over the years, Gottlieb was instrumental in establishing the department's Preceptor Group, the members of which share a passion for good pedagogy and the student experience. The group's collective activities have supported teaching and learning in the department. They have made a big difference here and, as preceptors move on to positions across the country, they continue having an impact on the places where they land.

"The whole system has morphed over the past 40 years," Gottlieb reflected. "There's much more coordination of courses and reflection on what worked and what didn't. And there's also much more support for graduate student teaching via not only the teaching apprenticeship program, but also through the calculus coach program and Math 303, "Teaching Undergraduate Mathematics." Gottlieb has been teaching the latter since the course's inception, first alongside Jameel Al-Aidroos, and then alongside Brendan Kelly and department pedagogy fellows. This coming fall she will teach it for the final time.

Gottlieb has also maintained an interest in how socio-economic status, race, and cultural differences impact math education in the U.S. The Emerging Scholars Program she started in 2016—after an initial attempt in 2006—is a result of this. The

Robin Gottlieb and son Amani, traveling through China.

program is driven by the principles of social justice and centers around equity, diversity, and inclusion in STEM fields. It is an enrichment-focused program designed to support first-year students passionate about pursuing a career in STEM and who are also enrolled in Math M, "Introduction to Functions and Calculus," a course Gottlieb developed several decades ago.

A career with an emphasis on teaching first-year college students has made Gottlieb particularly interested in student experiences in middle and high school math classes. Looking at these experiences from the perspectives of pedagogy, the goals of math education, equity, and challenges of change has been at the heart of the freshman seminar she has been teaching.

As she leaves her present position, she is interested in investigating change in mathematics education both in the U.S. and in other countries. During her upcoming sabbatical Gottlieb plans to explore issues around educational change and work with teachers to reimagine their approach in the classroom so that it is more closely aligned with their goals. She also hopes to travel once again. Her adventurous spirit and neverending curiosity have seen her teach math in China and Italy, write a textbook while traveling through Egypt, Turkey, and Nepal, and visit Peru with her son. She loved every minute of it and hopes to revisit the thrill of exploring the new and unfamiliar.

She is also looking forward to getting back in touch with her artistic side. "I was certainly not known for math in high school," Gottlieb said. "I was known for artwork. I even applied to college with a portfolio." She hopes to arrange her life in a way that will give her the time to pursue things completely separate from math and teaching. "There's no shortage of things that I'm interested in," Gottlieb said. "And I'm looking forward to having time to explore."

Emmy Noether Takes Center Stage

A Theater Performance About the Life of One of History's Most Influential Mathematicians

On a warm Saturday in September 2022, the Harvard Department of Mathematics and the Center of Mathematical Sciences and Applications (CMSA) hosted a unique event celebrating the life and achievements of renowned German mathematician Emmy Noether. Produced by Austrian ensemble portraittheater Vienna and German research university Freie Universität Berlin (FU), "Diving Into Math with Emmy Noether" is a biographical play based on historical documents and events. The multimedia show brings Noether's fascinating personality to life through a combination of actress Anita Zieher's performance and videos of dramatized conversations with other leading mathematicians of Noether's day. The event may have been years in the making—with discussions between Harvard and portraittheater beginning prepandemic—but it was more than worth the wait for the guests lucky enough to attend.

Emmy Noether was one of the most influential mathematicians of the last century. Her works and teachings left a lasting mark on modern algebra, opening new avenues for a modern structural perspective on mathematics. Born in 1882 in Erlangen, Germany, she began her studies in a time when women were only beginning to break down the barriers that prevented them from entering the doors of German universities. Noether worked at the Mathematical Institute of Erlangen for seven years without pay and had to overcome fierce resistance when she applied for the right to teach at the University of Göttingen in 1915. After four years of lecturing under another faculty member's name, she submitted a thesis in which she solved one of the central problems in Albert Einstein's general theory of relativity, at last acquiring her habilitation, her certification to teach.

She remained a leading member of the Göttingen mathematics department, where her students became known as the "Noether boys." Conversational mathematics played an essential part in her work and she inspired many leading figures worldwide, including Pavel Alexandrov, Jean Dieudonné, Hermann Weyl, and Norbert Wiener. When Hitler came to power in 1933, Noether was one of the first Jewish instructors to be dismissed by the Nazi government. She accepted a temporary appointment as a research professor at Bryn Mawr College and moved to the U.S., where she remained until her death in 1935. By that time, her algebraic acumen and her remarkable contributions toward understanding the status of conservation laws in relativity theory were recognized around the world. Following her death, Einstein himself wrote to The New York Times that she was "the most significant creative mathematical genius thus far produced since the higher education of women began."

Noether's extraordinary life and accomplishments could not have made her a better candidate for a portraittheater production. The Viennese theater ensemble specializes in bringing the life and work of extraordinary persons, especially women, to the stage. Since 2006, the company has produced plays about historian Hannah Arendt, philosopher and feminist activist Simone de Beauvoir, and physicist Marie Curie, among others. "We were performing a new play about the physicist Lise Meitner at the Universität Berlin in 2018, and Mechthild Koreuber

Emmy Noether, and Anita Zieher as Emmy Noether.

came to see it," recalled portraittheater director Sandra Schüddekopf. Mechthild, a historian of mathematics, author of a standard study of Noether's career, and chief gender equality officer at FU, had just organized a conference celebrating the 100th anniversary of Noether's habilitation. "She asked whether we would consider making a play about Emmy Noether," Schüddekopf said.

In preparing for their plays, portraittheater frequently cooperates with scientific advisors for an accurate representation of their fields of work. For "Diving Into Math with Emmy Noether," the company utilized Mechthild and David Rowe, a historian and mathematician from Mainz University. Following the play's successful debut in 2019, the ensemble considered bringing the performance to the U.S. After all, Noether had spent a part of her academic career there. When the pandemic struck, Rowe and Schüddekopf worked to translate the play from German, while Anita Zieher learnt to portray Noether in English.

"We worked to create a text that would meet the expectations of mathematicians as well as a general audience unfamiliar with mathematics," Zieher said. Although she is the only person on stage during the performance, she doesn't consider it a one-person show. "We show video sequences in the play in which Emmy is talking with mathematicians Bartel Leendert van der Waerden, Helmut Hasse, Pavel Alexandrov, and Olga Taussky-Todd," she said. "These sequences are really important for understanding the attitude and methods of Emmy Noether, who loved doing mathematics not in isolation, but in dialogue with colleagues."

Ironically, the forced isolation of the pandemic pushed portraittheater's U.S. tour back by years "It was hard to postpone twice," Schüddekopf said. "We were more than happy to finally be able to go on tour with the Noether play." Rowe was particularly tenacious in putting together the schedule that eventually brought the performance to Harvard's Student Organization Center at Hilles (SOCH).

A lively panel discussion preceded the play and brought additional excitement to the event. The panelists included Rowe and Emmy Noether's grandniece, Monica Noether, as well as Harvard Mallinckrodt Professor of Physics Melissa Franklin and Harvard Gerhard Gade University Professor Barry Mazur. The performance was followed by a reception, where guests got the chance to mingle and meet members of the ensemble. "We loved meeting Emmy's grandniece and being addressed as "Tante Emy,"" said Zieher. "So many guests lingered on to share their excitement over the play and congratulate us on our show." Schüddekopf's favorite moment of the night was when she overheard Mazur sharing how much he had enjoyed the performance without realizing that Zieher, unrecognizable out of her "Emmy Noether" costume, was standing right beside him.

Andrew Gleason in Black and White

Found Film Offers Glimpse of Department Past

It was a business-as-usual day in the fall of 2022 when a small but meaningful piece of department history was unearthed while cleaning out a third-floor office in the Harvard Science Center. A heavy, brown case sat innocuously on a shelf, safekeeping a 16mm black-and-white film shot in 1966. On it, Harvard professor emeritus Andrew Gleason gives an hour-long lecture about nim—a mathematical game of strategy in which two players take turns removing objects from distinct heaps or piles—and other oriented-graph games. More than a recording of an old lecture, the film is a time capsule. Frame by frame, it brings to life a mathematician who left an indelible mark on our department, made fundamental contributions to widely varied areas of mathematics, and was a leader in reform and innovation in mathematical pedagogy at all levels of education.

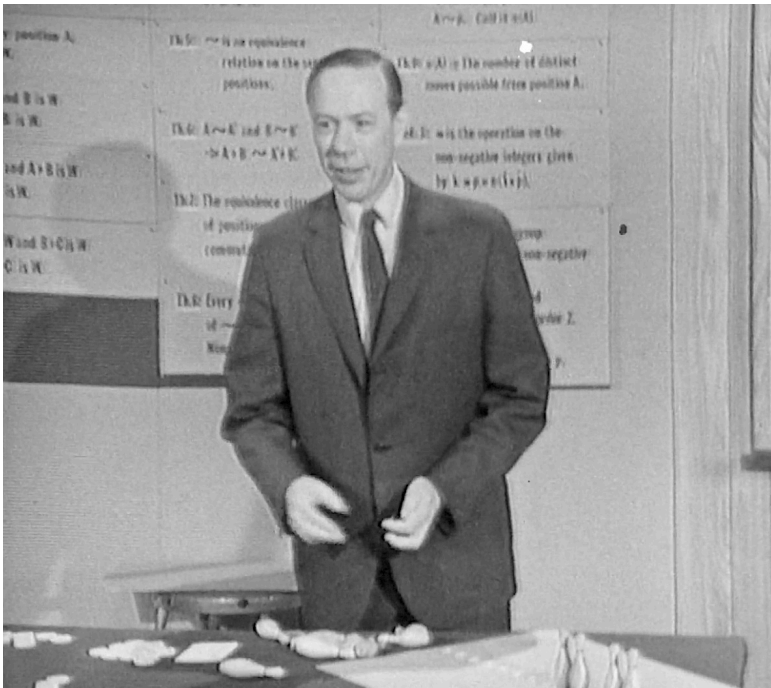
Preserving the Past for the Future

Department staff and faculty quickly took steps to preserve the film. This included procuring the services of a company that specializes in scanning motion picture film to digital files, Gamma Ray Digital. After a closer look, company president Perry Paolantonio identified it as a kinescope. “In the early days of television and before videotapes, they had to come up with a way to preserve live television broadcasts,” Paolantonio said. “A kinescope is a specialized film camera that’s pointed at a cathode-ray tube (CRT) display and records the video image to film.”

Our particular film was shot in a lecture hall using several video cameras routed into a switcher to cut between cameras. The effect of one angle cutting to another is accomplished live in the switcher during the lecture. The kinescope would have recorded the output of that switcher directly to our film.

That film was meant to be viewed in a dark room and was engineered with the human vision system in mind. It contains a lot more information than some scanners are able to pick up as its dynamic range is greater than most digital sensors. The scanner Gamma Ray Digital used is a very high resolution digital camera designed to capture everything to any of the common media file formats used for digital motion picture work. It helped that the film was in good physical condition, as well, with very little shrinking or warping.

It was also fortunate that it had not succumbed to “vinegar syndrome.” This type of degradation is inherent in the chemical nature of cellulose acetate plastic and its symptoms include a pungent vinegar smell (hence the name), followed eventually by shrinkage, embrittlement, and buckling of the gelatin emulsion. The progress of vinegar syndrome depends largely on storage conditions, but once it begins the process is irreversible and only speeds up as it goes along. The cool, dry conditions of the office in which the film was stored all these decades had spared it that fate, allowing us a glimpse of a mathematician in his prime.



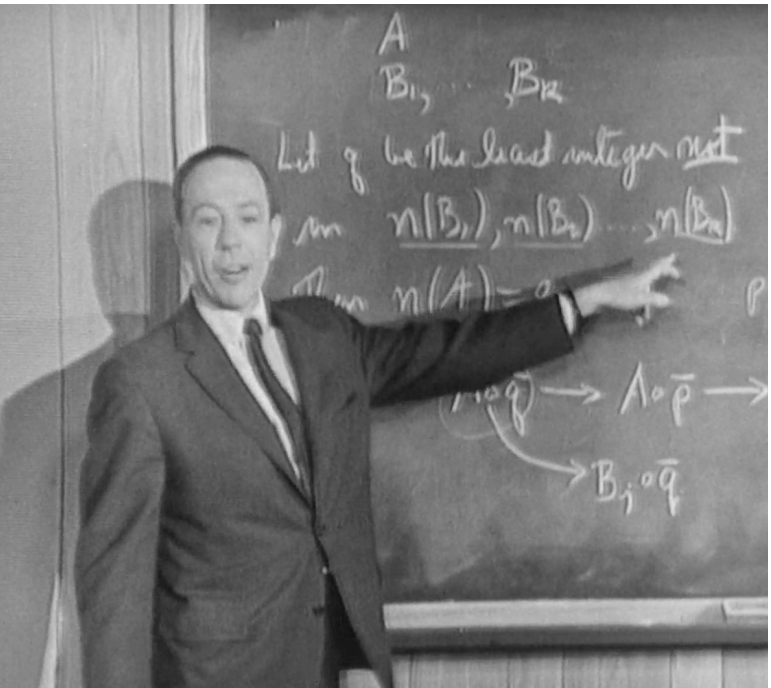
The Man on Film

California-born Andrew Gleason graduated Yale University in 1942, only to enlist in the Navy where he served as a cryptanalyst during World War II, cracking Japanese and German codes. He re-enlisted in 1950 and served as a code breaker in the Korean War for three years. His entire academic career, however, was spent at Harvard University, starting in 1946 when he was appointed a Junior Fellow of the Society of Fellows, a select group of young scholars given three year fellowships to pursue their studies without formal requirements. At that time, to be a Fellow meant he could achieve an academic career without having a Ph.D. And indeed, despite all he accomplished throughout his lifetime, Gleason never did pursue a doctoral degree.

Instead, he set about solving Hilbert's Fifth, a problem that mathematician David Hilbert formulated in 1900. Gleason solved a key aspect of the problem alongside three others, which earned him the Newcomb Cleveland Prize from the American Association for the Advancement of Science in 1952 and respect in the world of mathematicians. Among theoretical physicists and philosophers concerned with the foundations of quantum mechanics, he was famous for Gleason's theorem, elucidating a key point in quantum logic.

In 1969, Gleason was named the Harvard Hollis Professor of Mathematics and Natural Philosophy, the oldest endowed chair in the sciences in the United States. He became a Senior Fellow of the Society of Fellows in 1977 and chair from 1989 to 1996. Gleason received the Yueh-Gin Gung and Dr.

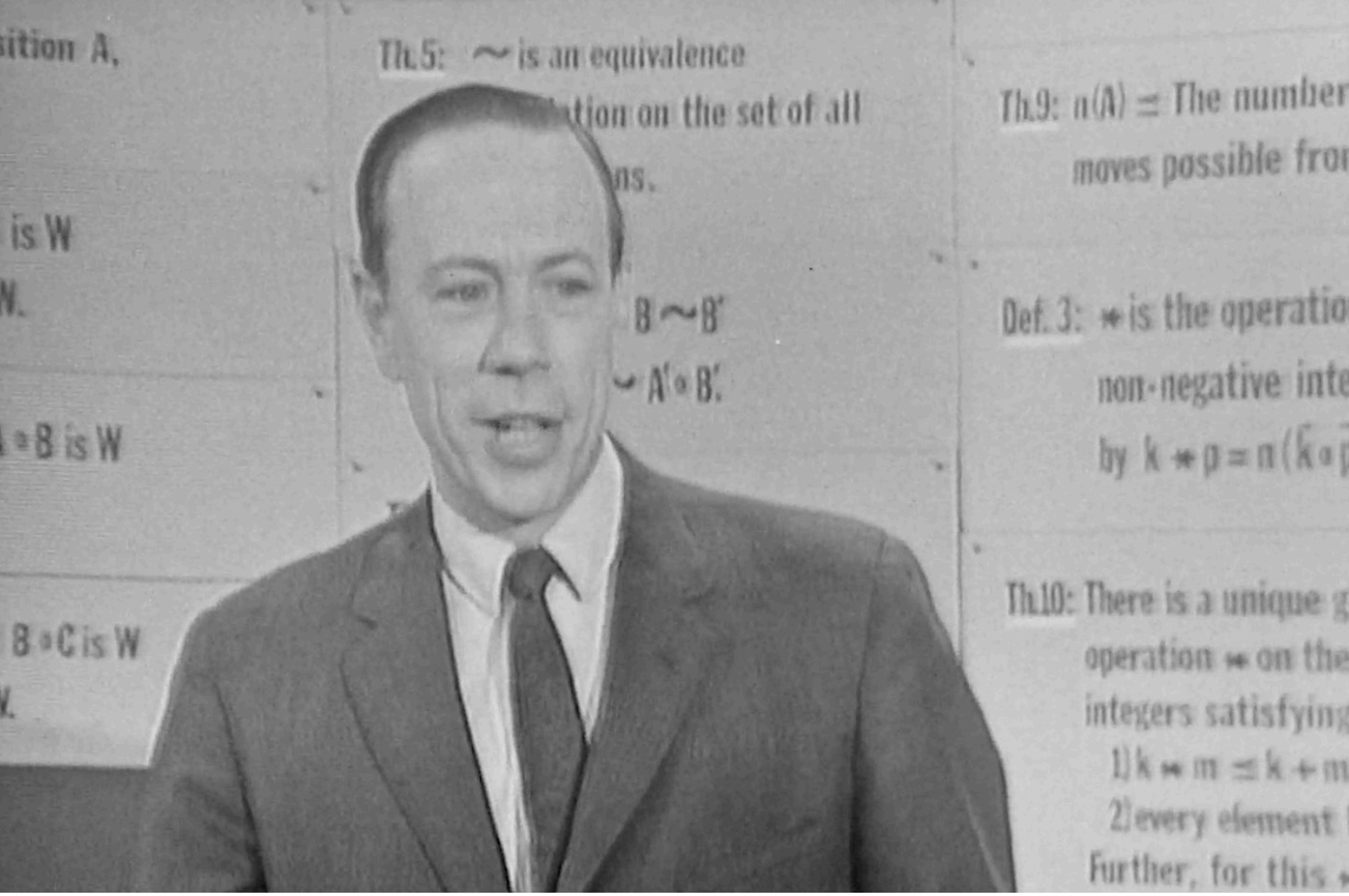
Professor emeritus *Andrew M. Gleason lectures on nim and other oriented-graph games.*



Charles Y. Hu Award for Distinguished Service, the Mathematical Association of America's most prestigious award, and served as president of the American Mathematical Society from 1981 to 1982. Despite his impressive list of accomplishments, honors, and awards, Gleason was most well-known among the people closest to him for his love of teaching.

"Anybody who knew Andy knew he was really interested in his students," said his wife and prominent psycholinguist Jean Berko Gleason, *professor emerita* in the Department of Psychological and Brain Sciences at Boston University. "He respected them but he also didn't want them to just learn formulas. He wanted them to understand the underlying principles of mathematics." It was a well-known fact that Gleason genuinely enjoyed helping other people with math. According to Berko Gleason, he frequently helped his fellow Yale students complete their homework.

Gleason's interest in the training of mathematicians led him to edit a compendium of three decades of William Lowell Putnam mathematical competition problems. At Harvard, he regularly taught at every



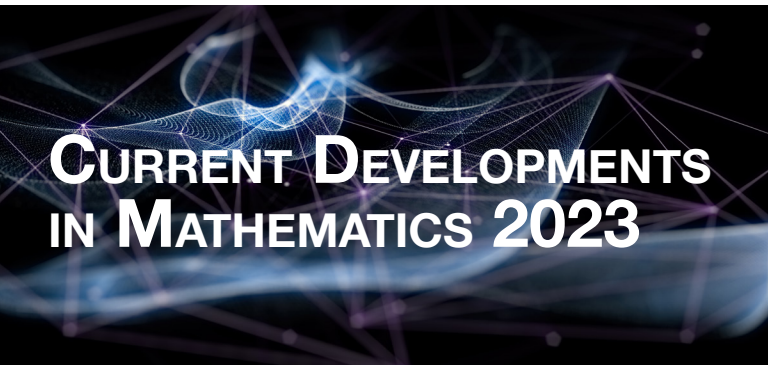
level and was always engaged in math curriculum reform. He helped found the Calculus Consortium in 1986, which went on to publish an influential series of calculus reform textbooks for college and high school. Gleason was also the first chairman of the advisory committee that helped define New Math, a unique teaching approach briefly used in the United States during the '60s that embraced abstract reasoning and conceptual understanding of the principles of mathematics, and de-emphasized technical computing skills.

Professor emeritus Benedict Gross took Math 55 with Gleason in 1968-69 as an undergraduate student at Harvard, and later had him as his thesis advisor. "He made outstanding contributions to mathematical research and was one of the most talented and committed teachers in the department," Gross said of his time as Gleason's student. "His lectures were beautifully organized and he often provided mimeographed hand-written notes. His clarity of thought and his willingness to interact with undergraduates persuaded many of us—myself included—to enter the field of mathematics."

Gross recalled that after graduating, he didn't feel quite ready to dedicate himself to mathematics. Gleason advised him to take a year off, which he did on a traveling fellowship. "Once I was ready to return, it was his support that got me into graduate school," Gross said. "I owe him a very great debt."

All of this comes through in the man lecturing in black and white all the way from 1966. The film shows someone comprehensible, clear, and to the point, whose formulations carry a scintillating precision delivered with enthusiasm and wide-eyed wonder. "He was a man who never raised his voice and enjoyed mathematics too much to get caught up in fights with people," Berko Gleason recalled. "When we got married, his mother wrote me a letter telling me how pleased she was that I was getting married and that I would be happy to know that her son was extremely even-tempered."

Notable Department Events



Current Developments in Mathematics, April 7-8, 2023

Speakers:
Amol Aggarwal | Columbia
Bhargav Bhatt | IAS/Princeton/UMichigan
Paul Bourgade | NYU Courant
Vesselin Dimitrov | IAS/Georgia Tech
Greta Panova | USC

Jameel Al-Aidroos Mathematical Pedagogy Lecture Series Oct 17, 2022

Speakers:
Juliana Belding | Boston College
Aubrey Clayton | Author

Diving Into Math with Emmy Noether Sept 10, 2022

A theatre performance about the life of one of history's most influential mathematicians.

Panelists:
Melissa Franklin | Harvard
Barry Mazur | Harvard
Monica Noether | Grandniece of Emmy Noether
David Rowe | Mainz University

The Circle at Infinity: An International Colloquium in Honor of Curtis T. McMmullen, June 15-17, 2022

Speakers:
Serge Cantat | Université de Rennes
Danny Calegari | University of Chicago
Laura DeMarco | Harvard University
Benson Farb | University of Chicago
Michael Freedman | Microsoft
John Hubbard | Cornell/Unversité de Provence
Hee Oh | Yale
Peter Sarnak| Princeton
Dennis Sullivan | Stony Brook/CUNY
Anton Zorich | CNRS-Université

Department Honors and Awards

2022 Abel Lectures Speaker

George Putnam Professor of Pure and Applied Mathematics and Harvard Department of Mathematics Chair Michael J. Hopkins

2022 American Academy of Arts and Sciences Elected Memter

Perkins Professor of Mathematics and Director of Graduate Studies Mark Kisin

2022 Chern Medal

Harvard Gerhard Gade University Professor Barry Mazur

2022 MacArthur Fellowship

Harvard Professor of Mathematics and Radcliffe Alumnae Professor Melanie Matchett Wood

2023 Steele Prize for Seminal Contribution to Research

Harvard William Caspar Graustein Professor of Mathematics Peter Kronheimer and MIT Singer Professor of Mathematics Tomasz Mrowka

Undergraduate Achievements

David B. Mumford Undergraduate Mathematics Prize

Benjy Firester ’23

Herb Alexander Prize

Sílvia Casacuberta Puig ’23

Friends Prize

Shared by undergraduate students Benjy Firester ’23 and Madison Shirazi ’23

Putnam Competition

Harvard undergraduate students who finished in the top 500 out of 3,415 students taking the exam:

Presto Bushnell ‘26 | Elliot Chin ‘25 | Tanav Choudhary ‘26 | Kevin Cong ‘26 | Andrew Courtney ‘23 | Deuce Ditton ‘25 | Drake Du ‘26 | Dhruv Goel ‘23 | Andrew Gu ‘26 | Justus Heeb, Visiting Undergraduate | William Hu ‘25 Michael Hwang ‘23 | Arav Karighattam ‘23 | Hahn Lheem ‘23 | David Li ‘25 | Jerry Liang ‘26 | Nicholas Lopez ‘25 Erik Mjaanes, Visiting Undergraduate | William Nickols ‘24 | Andrew Park ‘26 | Jinho Park ‘26 | Daniel Salkinder ‘26 Ilaria Seidel ‘26 | Eric Shen ‘25 | Daniel Sheremeta ‘25 | Easton Singer ‘26 | Lillian Sun ‘26 | Benjamin Tang ‘24 Katherine Tung ‘25 | Gabriel Wu ‘25 | Walden Yan ‘24 | Gil’i Zaid ‘26 | Alex Zhang ‘25 | Daniel Zhao ‘24

Wister Prize

Raphael Tsiamis ’23

Visit our website for the full list of honors and awards, including those announced after April 30, 2023.

Credits

PRODUCTION MANAGER

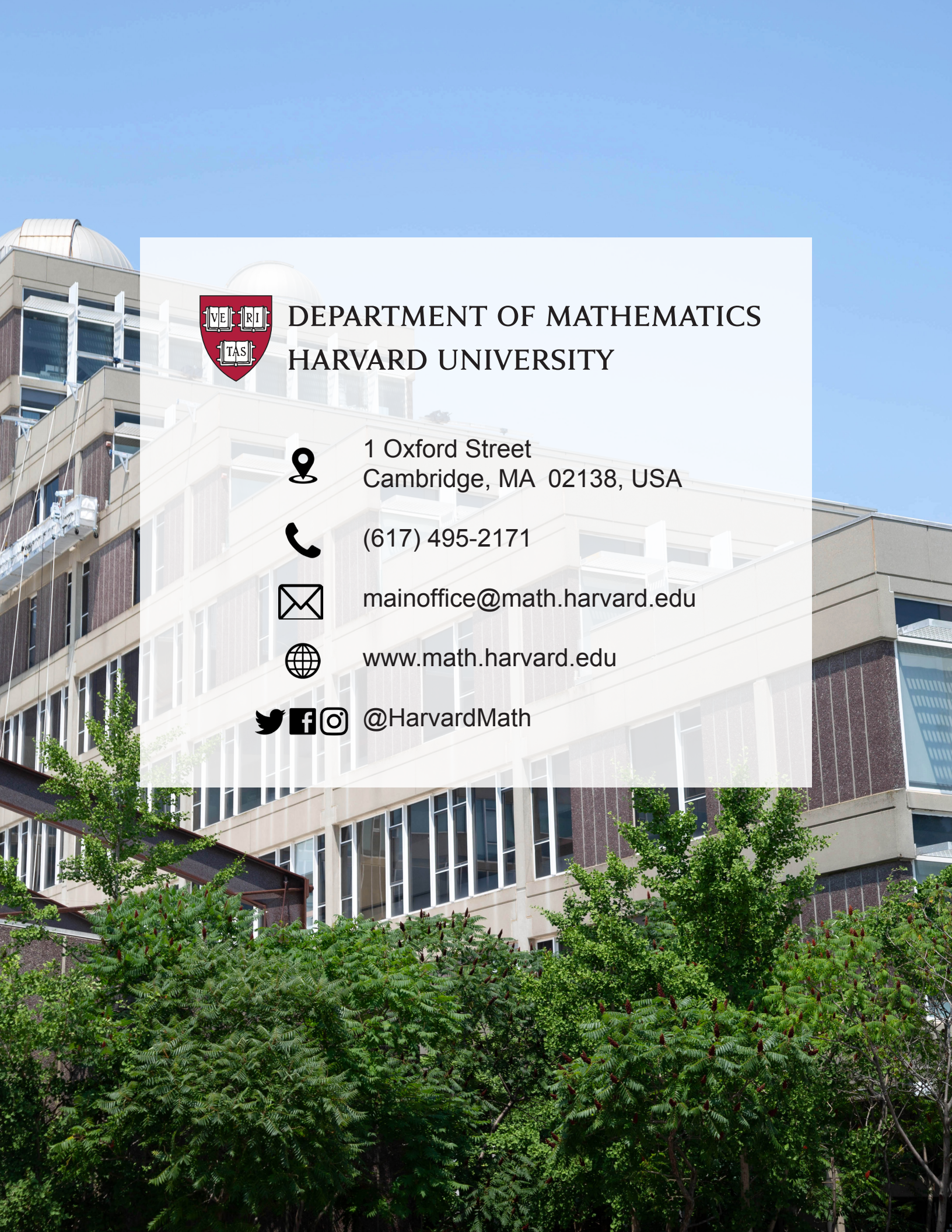
Anastasia Yefremova | Publications Coordinator

CONTRIBUTORS

Maureen Armstrong | Publications Coordinator (CMSA)
Marjorie Bell | Graduate Program Administrator
Dusty Grundmeier | Associate Senior Lecturer
Michael Hopkins | Professor of Mathematics, Department Chair
Cindy Jimenez | Undergraduate Program Coordinator
Irene Minder | Executive Director
Mark Kisin | Perkins Professor of Mathematics, Director of Graduate Studies
Cliff Taubes | Professor of Mathematics, Director of Undergraduate Studies

PHOTOGRAPHY

Oliver Knill | Preceptor, Digital Media Specialist
Anna Kreslavskaya | Assistant Director of Research and Finance



DEPARTMENT OF MATHEMATICS
HARVARD UNIVERSITY

1 Oxford Street
Cambridge, MA 02138, USA

(617) 495-2171

mainoffice@math.harvard.edu

www.math.harvard.edu

@HarvardMath