NEWSLETTER

MATHEMATICS

Harvard University Department of Mathematics

Academic Year 2021-2022

DEPARTMENT OF MATHEMATICS
HARVARD UNIVERSITY

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Message From the Chair

Michael J. Hopkins

George Putnam Professor of Pure and Applied Mathematics

Mathematics Department Chair

Dear Friends,

This past year has been one of reconnecting, of building new relationships and renewing old ones. As we have gradually transitioned back to in-person meetings, classes, seminars, and social events it has become clear just how valuable and just plain enjoyable it is to be together. Our classrooms were filled with a noticeable energy, and there was an elevated sense of excitement about learning.

Many of us found teaching this year to be especially fulfilling.

This year also marks the retirement of Professor Shing-Tung Yau, who leaves our department after 35 years of service. Beyond his scientific work, Yau was the driving force behind the creation of Harvard's Center of Mathematical Sciences and Applications (CMSA), aimed at connecting the Department of Mathematics with innovations and questions in pure mathematics arising from advances in science and technology. You can read more about that in a special feature in this newsletter.

We are also pleased that Brendan Kelly has accepted the newly created position of Director of Introductory Mathematics. He inspires great hopes for the future of our introductory math program. Brendan begins this position on July 1.

In this issue of our annual newsletter you will find profiles of some members of our community, as well as pieces highlighting the accomplishments of others. I hope you enjoy reading about some of the wonderful things that happened in this year of new beginnings.

With Best Wishes,

Mike Hopkins

Special Feature

Shing-Tung Yau | William Caspar Graustein Professor of Mathematics

Professor Shing-Tung Yau has been a leader in the fields of mathematics and physics since the early years of his academic career, with a reputation as a thinker of unrivaled technical power. As a pure mathematician, he has played a major part in building up differential geometry, the study of curves and surfaces. Yau is well-known for inventing the mathematical structures known as Calabi-Yau spaces that underlie string theory, the supposed "theory of everything." His work has earned him the Fields Medal, the National Medal of Science, a MacArthur Fellowship, the Crafoord Prize, the Veblen Prize, and the Wolf Prize, among other awards and honors.

Yau has also been a part of Harvard's Department of Mathematics for 35 years. Here, he has left a deep and lasting impression as an instructor, researcher, chair, and founder and director of the Center of Mathematical Sciences and Applications (CMSA). We celebrate all that Yau has done for his students, colleagues, and the world of mathematics at the end of his final year at Harvard University.

Born in 1949 in Shantou, a mountain town in China's Guangdong Province, Yau grew up in Hong Kong as one of eight children. His parents — a college professor and a librarian — were academically-minded themselves. Over the years, scholarly conversations with his father instilled in Yau a love of literature and philosophy, as well as a taste for abstract thinking, which was especially useful once he began seriously studying math. "I learned the beauty of it when I was in high school," Yau recalled. "That's when I started learning geometry, which I think is a really beautiful subject. It applies to physics, to industries, to engineering, and it's all exciting to me."

He studied math at the Chinese University of Hong Kong for three years before he won a scholarship to the University of California, Berkeley, which he graduated in 1969. In the late 1970s, he made a series of breakthroughs that helped launch the string theory revolution in physics and earned him the Fields Medal in 1982. Yau was one of the youngest mathematicians ever to be appointed to the permanent faculty of the Institute for Advanced Study in 1980. He has also taught at the State University of New York at Stony Brook, and Stanford University.

Yau was first approached by Harvard in the fall of 1979, when Dean Henry Rosovsky offered him a place at the Department of Mathematics. "It was an exciting opportunity," Yau remembered. "There were mathematicians in Harvard's math department whom I admired greatly, such as Heisuke Hironaka, John Tate, and Raoul Bott. Some of the subjects they focused on were influential in my own work, and I'd heard a lot of good things about the students, as well." However, it wasn't until 1987 that circumstances lined up just right and Yau was able to officially join

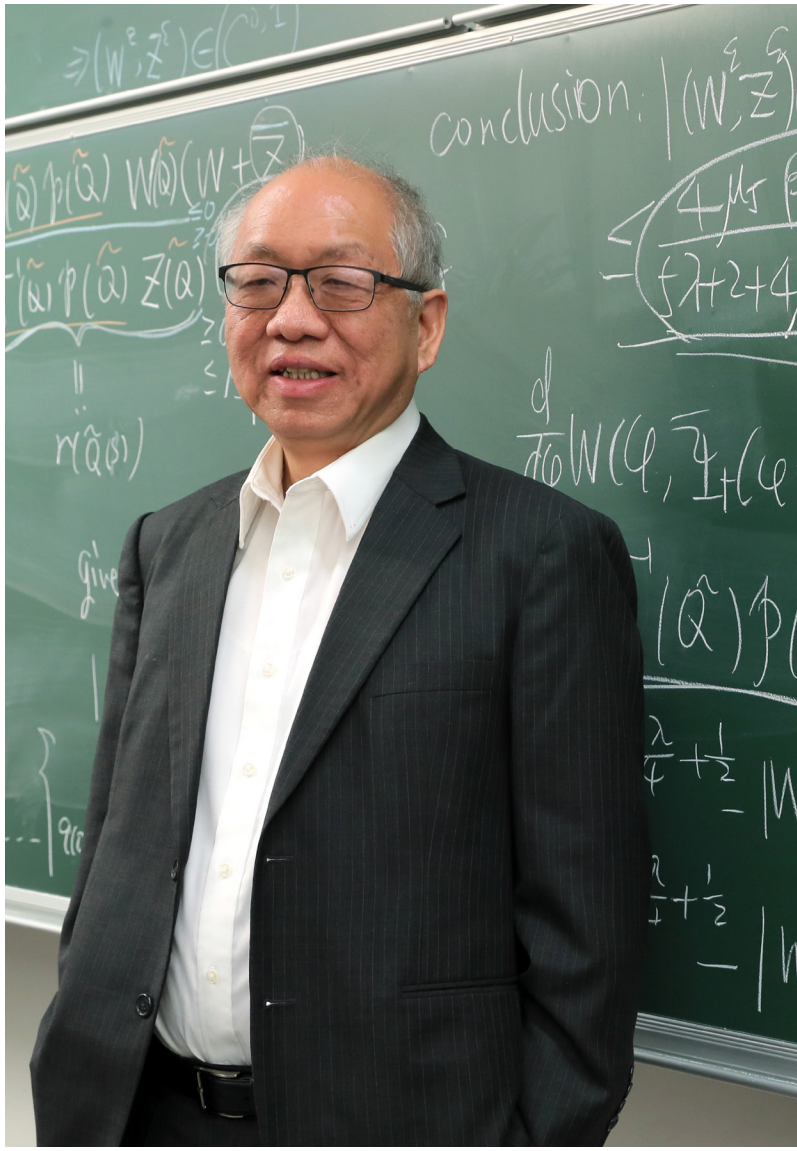
the Harvard community.

“I’ve enjoyed my time here very much,” he said. “I’ve been able to do many things that wouldn’t have been possible otherwise.” For 35 years, Yau was surrounded by an intellectually stimulating group of students and colleagues from some of the best colleges and universities in the country. He has collaborated with mathematicians, physicists, and students, conducted his own research, and organized a number of seminars and conferences. The most memorable of those for Yau is an international lecture series he started in the mid-90s in collaboration with the Massachusetts Institute of Technology (MIT). For years, the Current Developments in Mathematics (CDM) series would bring together five mathematicians from around the world to the Boston area to present on the latest developments in mathematics.

“The math department at Harvard is probably the best in the world,” Yau said. “But it’s largely focused on pure mathematics. And this is great, but there are other areas of mathematics that are just as important but that were not as well represented at the department as they could have been.” This is where the Harvard Department of Mathematics’ CMSA comes in. Founded in 2013, it is a multidisciplinary research center that brings together researchers from an extensive variety of fields and institutions.

The CMSA focuses on both mathematics research and its applications, and serves as a fusion point for mathematics, statistics, physics, and other sciences. “I think it is an opportunity for students and faculty to learn the kind of mathematics that they would have been less exposed to without the Center,” he said. Today, the CMSA is an established part of the Faculty of Arts and Sciences and the Department of Mathematics, hosting field postdocs, faculty, and various workshops. It holds weekly seminars on topics such as large data analysis, three-dimensional imaging, gravitation theory, mathematical analysis, conformal geometry, probability theory, and mathematical aspects of quantum and statistical physics. It also helps fund new professorships, research, and core programming. Yau was the CMSA’s first director.

He became chair of the Department of Mathematics in 2008, just in time to steer it through the financial crisis gripping the nation. Yau is happy to say he was able to protect the department’s budget in those tumultuous years and even raise additional funds. In



2009, he hired the first woman in mathematics to be tenured at Harvard University, French mathematician Sophie Morel. “I was proud of our department,” Yau said.

As the pandemic swept the world in 2020 and Harvard transitioned from in-person to remote learning, Yau took a one-year sabbatical and returned to China. There, he continued his work with students and fellow mathematicians. He also began considering early retirement. “I was already 70 years old,” he said. “I thought it might not be good for the department and Harvard in general to have too many old faculty members.” Yau retires in the spirit of innovation and entrepreneurship he has embodied for the entirety of his career as a mathematician. He has been a vital part of our department’s growth and development, and has enriched the mathematical lives of countless students and colleagues.

Faculty Spotlight

Barry Mazur | Gerhard Gade University Professor

Professor Barry Mazur, photo courtesy of Jim Harrison.

Professor Barry Mazur has been an indelible part of the Harvard University community for over 60 years. Over that time, his approach to mathematics, his work as an educator, and his understanding of the world at large have grown and evolved parallel with each other, as well as in the broader context of the University and the Department of Mathematics.

Today, Mazur is an internationally known mathematician recognized for his work in the advanced mathematical areas of topology and number theory. President Obama awarded him the National Medal of Science in 2013 and he is the recipient of the Leroy P. Steele Prize, the Cole Prize, the Chauvenet Prize, and the Oswald Veblen Prize among others. He is also an elected member of the National Academy of Sciences and the American Philosophical Society. But similar to the shapes Mazur encounters in his study of topology, his distinguished career is full of twists and turns.

His interest in mathematics — not that he knew it as such at the time — was sparked from his fascination with ham radio in high school. However, he wasn't drawn to the practical applications of electronics. Rather, he was enamored with the theories behind the applications, the ways in which energy could propagate through space. "If I actually thought of myself as anything at that time, I would have called myself a philosopher of electronics," Mazur recalled. After graduating from the Bronx High School of Science, he applied to and was accepted at the Massachusetts Institute of Technology (MIT). Mazur spent two years there and a year at Princeton University before he made his way to Paris. There, he "learned the sort of mathematics that was in the air at the time," he said.

While in Paris, he attempted to tackle the Poincaré conjecture, which had not yet been proven to be a true theorem. He started by proving what he called Lemma 1 — now known as Mazur's Lemma — but was unable to advance further. Once he returned to Princeton, he overheard Ralph Fox, the great knot theorist, discussing various open problems in topology. This included the Schoenflies problem. Mazur recognized it as his Lemma 1.

"The professor said if I could prove that, he'd get me into the Institute of Advanced Studies as a visitor," he said. Mazur was in the Institute the very next year. From there, he was introduced to the Harvard Society of Fellows as a Junior Fellow by noted mathematician Andrew Gleason.

In many ways, his three years at the Society of Fellows shaped Mazur.

In Harvard's Math Department he found himself surrounded by mathematicians such as Lars Ahlfors, Richard Brauer, Oscar Zariski, David Mumford, Heisuke Hironaka, Shlomo Sternberg, and many more. "Those were people who had, if not founded their fields, then at least left a significant imprint on those fields," Mazur said. "They were not only inspirations, but role models with utterly different approaches to teaching."

Mazur attended weekly dinners at the Society where high-level conversations varied across disciplines and specialties. This allowed him to develop into

the kind of mathematician who could discuss mathematics on any level and across disciplines with ease.

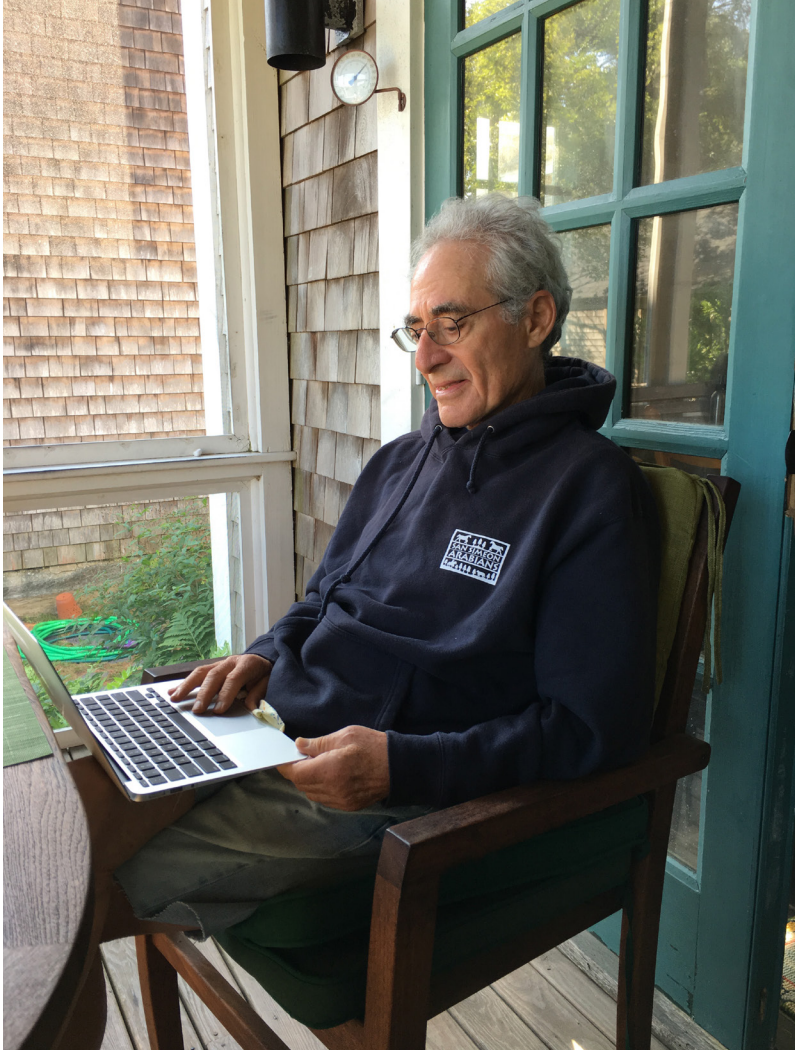
His research interests grew and evolved, as well. Mazur started out in topology, then for a brief time moved on to dynamical systems. In order to understand dynamical systems, he worked alongside MIT algebraic geometer Michael Artin. Through this collaboration, Mazur was drawn into algebraic geometry and, with time, into the broader algebraic and number-theoretic aspects of the subject. “I became most fascinated by number theory,” Mazur said. “And that’s where I am now.”

Throughout the evolution of his research interests and his career in mathematics, Mazur remained a part of the Harvard University community. He became an assistant professor in 1962, an associate professor in 1965, and a professor of mathematics in 1969. In 1982, he was named the William Petschek Professor of Mathematics and, in 1998, the Gerhard Gade University Professor.

The Gade University Professorship was established in 1960 to honor Gerhard Gade, a United States Foreign Service officer who bequeathed Harvard more than $1 million, half of which was used to establish the Gade professorship. It is awarded to distinguished individuals whose work is at the forefront of their field and allows them to teach in any department or faculty.

Mazur has co-taught courses across various departments both before and during his time as a University Professor. Those courses include seminars in the History of Mathematics (Euclid, Archimedes, Wallis, Newton) in the History of Science Department, a course in Immanuel Kant’s Critique of Judgment in the German Department, and a course called “The Nature of Evidence” at Harvard Law School.

Most recently, he co-taught a series of uniquely structured classes with philosopher and economist Amartya Kumar Sen and economist Eric Maskin called “Reasoning via Models,” “Utility,” “Axiomatic Reasoning,” “Objectivity/Subjectivity,” and “Truth.” The three are planning another addition to the series for the coming fall semester. The courses are limited in enrollment but are open to undergraduates, graduate students, and visitors. “We would shape the course starting from its name, using the backgrounds, experience, and interests of the students to inform



Professor Barry Mazur, photo courtesy of Gretchen Mazur.

its direction,” Mazur explained. “So, for example, if there are more mathematically-minded people, we would take things in a more mathematical direction.”

He has often found himself delighted and inspired by the students he has encountered over his years as an instructor and mentor. “One of the great blessings of being at Harvard is that you’re surrounded by students,” Mazur said. “And these students are committed, energetic, and enormously imaginative. You can either suggest an idea and let them go forth, or you can open yourself to their ideas and in turn be taught what they’re learning. It’s wonderful.”

Phil Matchett Wood

Senior Lecturer | Research Scientist

Dr. Phil Matchett Wood's history with the Department of Mathematics goes all the way back to his undergraduate days, when he received an A.B. *magna cum laude* in mathematics from Harvard University. After graduating with honors from the University of Cambridge, he attended Rutgers University for his PhD in mathematics. He returned to Harvard as a Lecturer of Mathematics and Research Scientist in 2020 and received a Harvard University Certificate of Teaching Excellence the same year. Wood was named Senior Lecturer of Mathematics and Research Scientist in 2021. His interests lie in probability theory and combinatorics, including random matrices and their eigenvalue distributions, Markov chains, structural behavior in sumsets, and using computers to explore problems in probability theory and combinatorics.

A Life of Mathematics

Math has been with Wood since a young age. "One of my parents is a mathematician so there were a few more mathematical concepts flying around the house than normal," he said. He was also involved in Mathcounts, a national middle school math competition that presents children with an unfamiliar problem and challenges them to solve it through clever and inventive use of what they already know. "In many ways, this was the first chance I got to be creative in mathematics," Wood said.

He was first drawn to math because it seemed to offer a definitive answer and a chance at a shared truth. "Even when I was little, I liked that part of mathematics," he said. "You can't have a persistent dispute in a mathematical context. In the idealized sense, there's going to be one statement that would be either true or false. Maybe we now know that a statement could be unprovable, but there would still be a part of it that you could completely clarify in one right way."

About Harvard

Having graduated from Harvard University in 2002 as a student, Wood returned in 2020 as a teacher and researcher. "My wife, Melanie Wood, is also a mathematician and our goal since graduate school has been to have jobs in the same town," he said. That goal took him to the University of Wisconsin-Madison and the University of California. "Those schools worked well for both of us and, as far as math departments go, are in a generally increasing sequence of quality of graduate students and general research enterprise." This eventually led the Woods to Harvard. "We're very happy to have come here already having experienced how welcoming the Department of Mathematics can be," Wood said.

One of his proudest achievements while at Harvard is his work mentoring undergraduate students giving colloquium talks for Math Table, an enrichment program developed for elementary and middle school students, elevated to an undergraduate level. "We have an undergraduate student present a talk on a mathematical topic that may be new and different," Wood said. "Not the kind of thing you'd necessarily see in your usual math curriculum, but still something that people can understand and have fun with. We have meetings every other Wednesday and I have a lot of fun mentoring students, and listening to them practicing and thinking about how to condense and simplify things to a 25-30 minute talk that really gets across the idea."

What little free time Wood has, he spends cross-country skiing. "We've had a reasonably snowy winter for those kinds of activities here," he said. "It's nice, especially coming from that year in California where we had to drive a good distance to find snow. Now I can find it in my backyard again."

Ana Balibanu

Benjamin Peirce Fellow

After graduating with honors from the California Institute of Technology, Dr. Ana Balibanu earned her PhD in Mathematics from the University of Chicago. She joined the Harvard University Department of Mathematics as a Benjamin Peirce Fellow in 2017 and received a National Science Foundation (NSF) Mathematical Sciences Postdoctoral Research Fellowship in 2019. During her time at Harvard, Balibanu has been awarded a Certificate of Teaching Excellence six times. Her area of research covers geometric representation theory with a focus on algebraic groups and their connections to symplectic and Poisson geometry.

A Life of Mathematics

Balibanu doesn't remember a time when she wasn't drawn to mathematics. "I always felt that it was beautiful and compelling," she said. "I was pretty young when I first realized I liked math so I didn't exactly have the capacity to look at it philosophically. I just knew I enjoyed doing it and learning about it, and that's something that has only grown over the years."

With time, Balibanu's research evolved to focus on geometric representation theory, a subfield of algebra with close connections to geometry. As an undergraduate student, she took a large number of algebra-focused classes. She even went into graduate school thinking she would pursue algebra as her field of study. "I was a very young student and didn't have a global view of what modern math research really looks like," Balubanu recalled. As a more experienced mathematician and graduate student, she specialized in a field of research that she didn't even know existed as an undergraduate student and that was a lot more geometric than she thought she liked.

"Geometric representation theory is a beautiful field because it blends two areas of mathematics," Balibanu said. "You're studying algebraic questions by trying to interpret them in terms of geometric objects and think about their geometry. And you're studying geometric questions by attaching algebraic data to them and computing with that algebraic data. It's that interplay that I've always liked." Since the completion of her PhD, her research interests have developed in new directions that involve more algebraic and symplectic geometry.

About Harvard

In some ways, Harvard's appeal to Balibanu was purely mathematical. Not only is the university's Department of Mathematics very active in her area of research, but so is Boston overall. She was attracted to the idea of being in a large community "that doesn't consist of just a handful of people in the department, but a city full of people all thinking about the same questions," she said. Her position as junior faculty also strikes a good balance between independence and responsibility, as Balibanu gets to teach courses she has developed herself. There are also student mentorship opportunities, as well as direct involvement with department life and committee work. "In this way, you get to know not only other postdoctoral students but people in all stages of their mathematical lives," she said.

Her time at Harvard has been a formative period professionally for Balibanu and stimulating in the mathematical sense. She had just completed her PhD when she joined the Department of Mathematics, "a freshly minted student," as she put it. Today, she considers herself much closer to adulthood in her mathematical life.

Hakim J. Walker

Preceptor

Dr. Hakim Walker joined the Harvard Department of Mathematics as a preceptor in 2017. A graduate of Boston University and The George Washington University, he has received numerous teaching awards and is a seven-time recipient of the Harvard Certificate of Teaching Excellence. He is involved with multiple student outreach and service activities, and coordinates the Harvard College Emerging Scholars Program, an academic enrichment program that seeks to support STEM-interested students enrolled in introductory calculus.

A Life of Mathematics

Walker's earliest memory is loving math. He remembers dreading readings and adoring basic arithmetic in kindergarten. His mother provided him with plenty of math-based logic puzzles, riddles, and games. In high school, Walker realized he loved helping his classmates with math just as much as he loved the subject itself. "I recognized that it came more easily to me than to a lot of my friends," he said. "And I wanted them to see what I saw and enjoy it the way that I did. Doing math and helping others with it have always just felt very natural to me."

He went to college with that love for math burning bright, but hit a wall in his sophomore year. "I got bad advising," he recalled. "I was told to take classes in an order that I shouldn't have, so I was hit with some really tough courses that made me question if I should even be studying math." Thankfully, he took a logic course in his senior year of college. It was the exact kind of math he had been waiting for and what inspired him to go to graduate school. He studied computability theory but his interest gradually evolved to how he could make students better math thinkers and himself a better teacher of mathematics. "It's hard to learn and teach math," Walker said. "That's the kind of thing that I want to think more intently about as I go further in my career."

He is especially passionate about undergraduate advising. "I think that some people in academia almost forget what it's like to struggle in their subject, since it's something they've been doing for their whole lives and it comes to them naturally," Walker said. "I've always wanted to be the advisor and teacher who puts himself in the mindset of his students, who meets them where they're at. That's the challenge that I really love, because even though the material stays the same, every student is different."

About Harvard

It was Walker's last year of grad school and his advisor, a word-renowned researcher, was urging him to follow in her footsteps. But Walker himself was much more interested in teaching-focused roles. He wanted to come back to Boston for the start of his career, and he wanted to be in a department and a culture that cared about growing mathematicians as well as helping both graduate and undergraduate students advance. And he found all that at Harvard.

"A lot of schools can show their intentionality by creating roles focused on particular ideals," Walker said. "It means a lot that Harvard has a dedicated preceptor role for experienced, established mathematicians who are also expert teachers and who care about crafting a course that tells a story, challenges students, is deep and enriching, and doesn't just give students problems to memorize by rote." He found himself surrounded by people who thought deeply about all elements of their teaching, from classroom management, to boardwork and use of handouts and examples. Walker knew he would grow as a teacher at Harvard, gaining new experiences. "I thought,I'm going to learn a lot from this place," he said. "And I was absolutely right."

Message From the Director of Undergraduate Studies

Cliff Taubes

William Petschek Professor of Mathematics

Director of Undergraduate Studies

Dear Friends,

Among the 247 mathematics concentrators, many of our 81 current sophomores had never taken a course in the Science Center prior to the 2021-2022 academic year. Thankfully, the careful relaxation of pandemic-related restrictions and the return to on-campus learning helped promote community both campus-wide and within our department.

This year saw the return of many in-person undergraduate events, including the Math Table and Open Neighborhood Seminars, as well as the regular Math Night gatherings organized by the Gender Inclusivity In Mathematics (GIIM) team. We also successfully introduced new courses such as Math Q: “Quantitative Analysis for Economics and the Social Sciences I and II”.

Our students worked so very hard over the past year. That was truly inspiring. And even more inspiring: we had 24 senior theses written by primary mathematics concentrators and many more written by math allied concentrators. The theses were uniformly first rate expositions of mathematics either pure or applied, with some containing ground breaking research in mathematics or related fields.

Congratulations to all.

We are encouraged by the interest in the program and are pleased with the level of talent shown by our students. Our goal is to continue to enroll those with a genuine love for mathematics and offer them an engrossing and, ultimately, rewarding experience as part of Harvard’s math community.

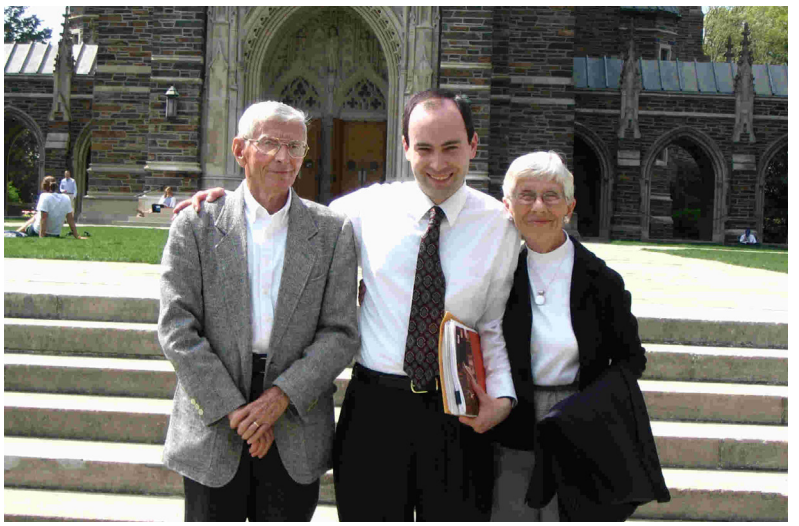
With Best Wishes,

Cliff Taubes

John Wesley Cain

Senior Lecturer | Assistant Director of Undergraduate Studies

Dr. John Wesley Cain's journey as a mathematician has in many ways parallelled his journey as a person. As a child, he recalls indulging his grandfather by solving simple arithmetic problems in front of friends and family. "It made him happy and it made him smile," Cain said. "And that stuck with me." The validation from a family member for something as staid as addition or basic arithmetic in turn made those activities fun.



Cain with his grandparents following his Ph.D. dissertation defense.

"When I started studying more advanced mathematics in high school, I liked it even more," he said. However, that did not mean that math was Cain's best subject; he admits that was probably Spanish. By the time college application time rolled around, he'd convinced himself that he wanted to pursue chemistry and chemical engineering. Even still, Cain couldn't imagine not taking math classes. "I thought I liked chemistry," he said. "But I've just never liked anything as much as I like math."

He completed his undergraduate training in theoretical mathematics at North Carolina State University and, after a year abroad as part of the Budapest Semesters in Mathematics program, was excited to pursue graduate studies in mathematics. However, around this time Cain began to question whether he would enjoy spending a career trying to prove new theorems as opposed to finding novel uses for existing ones. "I didn't want to do mathematics just for mathematics' sake," he said. "I was hoping to work on problems of interest in other fields."

Cain developed a passion for application-oriented mathematics during his first semester in the mathematics Ph.D. program at Duke University. He enrolled in a course that required him to complete a project selected from a list of topics, most of them theory-heavy. But one option jumped out at him: a study of equations that arise in the context of modeling cardiac action potentials. "I didn't know anything about cardiac electrophysiology at the time," Cain said. "I had never even taken a biology course in college, but I really liked the way that this particular project seemed to showcase how mathematics could inform problems that would be of interest to electrophysiologists."

During his second semester of graduate school, he kept in touch with the course instructor, Professor David Schaeffer. "Just as I was about to pop the question and ask if he'd be willing to be my academic advisor and continue the project, he asked if I'd be willing to be his graduate advisee," Cain recalled. "So I thought, 'this is a sign'. And that's how I got into applied math."

He met with biomedical engineers, clinicians, and physicists, and learned science he had never studied before, all to make sure that his math was grounded in problems of tangible importance to people's lives. Cain credits his graduate advisor for much of his academic and career development: "Professor Schaeffer was the best advisor anyone could hope for, and he will always remain the most influential figure in my academic life. He was patient with me, and continued to support me long after I took on my first faculty position."

As an associate professor at the University of Richmond, Cain approached a sabbatical year. He decided that if he was going to be in a liberal arts environment for the rest of his career — which is what he believed at the time — he needed to learn more about best practices regarding teaching calculus and linear algebra. So he reached out to Harvard's Professor Robin Gottlieb, an international leader in mathematics education at the college level. "I needed to get some research done during my sabbatical, but I wanted to grow not only as a researcher, but as a teacher as well," Cain said.

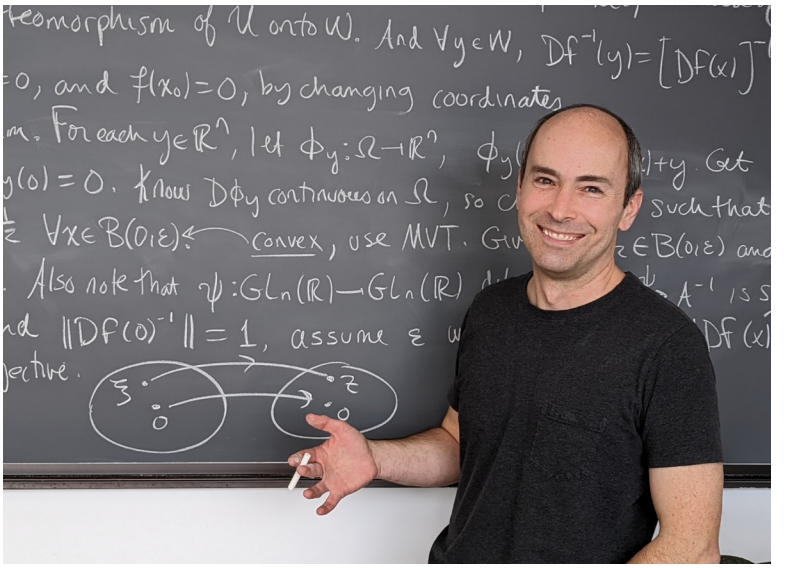
He joined Harvard's Department of Mathematics as a visiting associate professor from 2013 to 2014 and used his background in applied math to help renovate the "Math 19A: Modeling and Differential Equations for the Life Sciences" class. He also learned to manage an inquiry-based classroom, a student-centered approach where the instructor poses questions that lead students to "discover" key concepts and make their own conjectures. Under the guidance of two teaching teams — one led by Dr. Janet Chen, the other by Dr. Jameel Al-Aidroos — he completely rethought the way in which he teaches introductory courses.

"I knew that active and inquiry-based learning were shown to be more effective and engaging ways of learning, but I was nervous about relinquishing the chalk to my students. The preceptor team helped me learn how to lead an active classroom, and the experience was amazing," he said. "I went back to Richmond and used everything that I learned to completely overhaul the way that I taught calculus. I tried to be more of a tour-guide than a lecturer." Just one year after returning to Richmond, Cain accepted an opportunity to return to Harvard indefinitely. He joined the Department of Mathematics as a senior lecturer in 2015 and became Assistant Director of Undergraduate Studies in 2019.

Supervising undergraduate research projects has become one of Cain's top priorities. Collaborations with students have been a source of delight and inspiration over the years. "Serving as a senior thesis supervisor is incredibly educational for me, particularly when students suggest topics that are far removed from what I usually study," Cain said.

Some of his student projects have been incredibly productive; over the past two years, Cain has co-authored six research articles with former students. He and collaborators recently received an National Science Foundation (NSF) award for a continuation of one of those projects, which will enable him to recruit more undergraduate research students in the coming years.

One memorable and productive collaboration is that with Dr. Victor Luria, who has a joint postdoctoral appointment with Harvard Medical School and the Yale School of Medicine. The two met when Luria took Cain's "Math 19A" class in 2014. Based on Luria's class project, they remained in touch and co-authored a number of research articles. They are in the process of wrapping up another exciting project



together for which they have high aspirations. "We feel we have a really nice mathematical framework for explaining the emergence of novel genes within intergenic regions of the human genome," Cain said.

His affinity for inquiry-based teaching and mentorship have greatly influenced his hopes and vision for the future of the Harvard Department of Mathematics. "I encourage students to collaborate in small groups, and to establish norms that prevent the loudest and most vocal students from driving the conversation," Cain said. "I want to make sure that all of our students' 'mathematical voices' are being heard, never to be drowned out unfairly."

Cain strives to be an approachable figure to his students and colleagues, and to create a comfortable environment where people don't feel confined by their titles or the stages of their careers. "I'm really hoping that, as the years go by, we'll see students, faculty, and visitors mingle more freely, without partitioning themselves by career stage, job title, or coursework history," he said.

His main aspiration for the Department of Mathematics is for it to be a welcoming place for everyone. "I don't judge the quality of a mathematics department by its research output, or whether there are award-winning students or faculty," Cain said. "Those things don't matter to me at all. I am far more interested in how people interact with one another, the overall level of departmental morale, and whether everyone feels welcome."

As a faculty member and Assistant Director of Undergraduate Studies, Cain tries to do his part to promote a culture of inclusion: "As a department, we must always aspire to be more welcoming and to acknowledge that we can do better. I think we're trending in a good direction, and I'm very optimistic about our future."

Message From the Director of Graduate Studies

Mark Kisin

Perkins Professor of Mathematics

Director of Graduate Studies

Dear Friends,

On the heels of two unprecedented years, our 53 graduate students continue to show their creativity and resilience.

In-person classes resumed in the Fall and our 29 international students were all able to join us on campus. Students had the chance to meet in person again, and also make the most of new means of communication and collaboration.

Over the past year, our graduate students have received funding from Harvard University and the Department of Mathematics. Some were awarded grants from the National Science Foundation, the Natural Sciences and Engineering Research Council of Canada, the Kwanjeong Educational Foundation, the Forethought Foundation, and the P.D. Soros Fellowship for New Americans.

In particular, the department has continued to receive a generous contribution from the Putnam family that has provided support to 10 students this year. This funding is greatly appreciated and has had a significant impact on the work we do.

We welcomed seven new students this past fall, and a total of 11 students will be graduating this academic year. As in previous years, their job searches have been remarkably successful.

We hope to continue to bring together the best mathematics students in the world to form a vibrant and diverse community of scholars.

With Best Wishes,

Mark Kisin

Student Spotlight

Alexander Petrov | Clay Research Fellowship Recipient

Alexander Petrov is a ‘22 graduate of the Harvard University Department of Mathematics doctoral program and the recipient of the prestigious five-year Clay Research Fellowship. Fellows are employed by the Clay Mathematics Institute, a U.S. charitable foundation, but may hold their fellowships anywhere in the U.S., Europe, or elsewhere in the world. They are selected for their research achievements and their potential to become leaders in research mathematics, and many are chosen as they complete their thesis work. Clay Research Fellows are provided generous salaries and research expenses, which provides them the opportunity to focus exclusively on their research.

Petrov received the fellowship for his work in number theory. According to the Clay Mathematics Institute, he demonstrated exceptional creativity in proving surprising theorems concerning Galois representations and arithmetic local systems on algebraic varieties. Settling a conjecture of Litt, he proved that geometrically irreducible, arithmetic local systems on varieties over p-adic fields are essentially de Rham. Petrov discovered a deep generalization of Belyi’s famous theorem, and he opened a new range of possibilities with counterexamples to a conjecture of Scholze on Hodge symmetry for rigid analytic varieties.

We interviewed Petrov about his mathematical journey, his time at Harvard University, and what the Clay Fellowship means to him.

What drew you to math originally? What has it come to mean to you with time?

Both of my parents are scientists. My father in particular used to be a physical chemistry researcher so he knows a fair bit of math, and he enjoys it. I always liked it, too, but I only started seriously studying it in high school.

When I first started learning math, I enjoyed the rigor and the precision. But since I started doing my own research, I’ve essentially been treating it as part of the humanities. Or at least this applies to the style of mathematics that I do. I think it’s very important to read a lot of other people’s work, as well as to contemplate and understand the overall structure of the systems that you’re working with, rather than just solving specific problems. Mathematics, for me, exists for the joy of it.

There was enough math at the end of the 19th century for some really advanced engineering, so people could have decided that they had discovered all there was to discover and stopped there. But for some reason, every year somewhere around the world, people come across substantially new and interesting math ideas. In this way, mathematics is always evolving. The heuristic observation is that math is worth developing further and further, that it’s something worth pursuing for its own sake.

What has your time at Harvard University meant for you as a mathematician?

Before coming here for graduate school, I lived in Moscow, Russia. I was fortunate enough to be at a very good math department at the Higher School of Economics, where I met some incredible mathematicians and mentors. I was considering staying in Moscow for a master’s degree or a Ph.D., but a few of my mentors persuaded me that it’s a good idea to change locations for the sake of my mathematical development. I visited Harvard as a prospective student and saw that people seemed to be pretty happy here. It turned out to be a good choice and I found a wonderful advisor in Mark Kisin during my time here. He was instrumental in directing me to interesting, doable problems. His enthusiasm for math was always very important to me.

I knew relatively well what kind of mathematics I preferred when I started at Harvard, but I suffered from this misconception that I had to immediately do something impressive or solve some significant problem. I was putting a lot of pressure on myself. Normally, that can be a push forward, but I don't think I initially directed the pressure in the most productive way.

I spent the first two years of my time at Harvard attempting to re-prove the Fontaine-Mazur conjecture for Galois representation arising from p-adic modular forms using properties of the perfectoid modular curve. I eventually had to give it up, but some time later a postdoc at the University of Chicago did what I was trying to do in a somewhat similar way. So I'm actually quite happy at the fact that the approach seems to have been right and that it was possible to execute it.

What does being awarded the Clay Research Fellowship mean for you and your future plans?

I knew that I was nominated, but I was 99% sure that I wouldn't receive it. I looked at the laureates from previous years and I thought, well, clearly what I've done isn't up to those standards. So I was pleasantly surprised that they awarded it to me. It was nice to know that I could do research without having to also worry about teaching if I didn't need to. There are several other current graduate students and recent graduates who, in my opinion, would be equally deserving of this award. And while I'm glad that I received the fellowship, it would be nice if there were even more systems in place to support research mathematicians after graduation.

Following graduation, Petrov plans to conduct research as a Clay Research Fellow at the Max Planck Institute for Mathematics (MPIM).

First-Year Graduate Students

Ekaterina Bogdanova

Undergraduate Affiliation
HSE University

Research Interests
I'm interested in geometric representation theory, algebraic number theory, and algebraic geometry. Currently I am thinking about quantizations of symplectic schemes and moduli spaces of irregular local systems on projective line. I am also leaning towards geometric Langlands program.

Amanda Burcroff

Undergraduate Affiliation
University of Michigan, Ann Arbor

Research Interests
My main research interest is algebraic combinatorics, though I'm generally a fan of combinatorics of all flavors. Previously I have worked on projects involving hyperbolic Coxeter polytopes, graph domination, pattern avoidance, minimal additive complements, and combinatorics on words. I am currently thinking about problems involving cluster algebras and their quantum generalizations. I enjoy finding new combinatorial ways to describe their behavior, with the hope of using these results to better understand certain positivity properties.

Alice Lin

Undergraduate Affiliation
Princeton University

Research Interests
I am interested in algebraic number theory and arithmetic geometry.

Leon Liu

Undergraduate Affiliation
University of Texas, Austin

Research Interests
I am interested in the interaction between homotopy theory and physics, mainly anomalies and anomaly matching.

First-Year Graduate Students

Rafael Saavedra

Undergraduate Affiliation
University of Chicago

Research Interests
I am interested in dynamical systems. Currently I am interested in the use of Teichmüller theory for the study of both rational maps and translation surfaces.

Natalie Stewart

Undergraduate Affiliation
Massachusetts Institute of Technology (MIT)

Research Interests
I am interested in algebraic topology and homotopy theory.

Eunice Sukarto

Undergraduate Affiliation
University of California, Berkeley

Research Interests
I'm interested in learning about the universe through math, and learning math through the lens of algebraic topology.

Graduating PhD Students

Dexter Chua

Advisor: Michael Hopkins

Thesis
The E3 page of the Adams Spectral Sequence

What's Next
Working in the industry

Yuval Dor

Advisor: Ehud Hrushovski

Thesis
Transformal Valued Fields

Yuchen Fu

Advisor: Dennis Gaitsgory

Thesis
An Extension of the Kazhdan-Lusztig Equivalence

What's Next
Postdoctoral researcher at the Research Institute for Mathematical Sciences, Kyoto University & MIT

Si Ying Lee

Advisor: Mark Kisin

Thesis
Eichler-Shimura Relations

What's Next
Postdoctoral researcher at the Max Planck Institute for Mathematics & Stanford University

Tian Nie

Advisor: Mark Kisin

Thesis
Absolute Hodge Cycles In Prismatic Cohomology

Alexander Petrov

Advisor: Mark Kisin

Thesis
Arithmetic Properties of Local Systems on Algebraic Varieties

What's Next
Clay Fellow at the Max Planck Institute for Mathematics

Graduating PhD Students

Waqar Shah
Advisor: Barry Mazur

Thesis
On an Approach to Automorphic Euler Systems

What's Next
Visiting Assistant Professor at the University of California, Santa Barbara

Karl Winsor
Advisor: Curtis McMullen

Thesis
Dynamics and Topology of Absolute Period Foliations of Strata of Holomorphic 1-Forms

What's Next
Simons Postdoctoral Fellowship at the Fields Institute & Simons Instructor at Stony Brook University

Yujie Xu
Advisor: Mark Kisin

Thesis
Normalization in the Integral Models of Shimura Varieties of Abelian Type

What's Next
NSF Postdoctoral Fellow at the MIT and Joseph F. Ritt Assistant Professor at Columbia University

David Yang
Advisor: Dennis Gaitsgory

Thesis
Categorical Moy-Prasad Theory and Applications to Geometric Langlands

What's Next
Postdoctoral researcher at MIT

Yuxuan Yang
Advisor: Cliff Taubes

Thesis
Analytic Results on Seiberg-Witten Equations on Homology $S^1 \times S^3$

What's Next
Quantitative researcher at Vatic Investments

Faculty and Graduate Honors and Awards

2021 Fudan-Zhongzhi Science Award

Benedict Gross, Professor Emeritus

Jointly with Don Zagier of the Max Planck Institute for Mathematics

2022 Oswald Veblen Prize in Geometry

Michael Hopkins, Department Chair and George Putnam Professor of Pure and Applied Mathematics

Invited Lecture at the 2022 Quadrennial International Congress of Mathematicians (ICM)

Lauren Williams, Dwight Parker Robinson Professor of Mathematics

Special Sectional Lecture at the 2022 Quadrennial International Congress of Mathematicians (ICM)

Melanie Matchett Wood, Professor of Mathematics

Clay Research Fellowship

Alexander Petrov, Graduate Student ‘22

Undergraduate Honors and Awards

Thomas Temple Hoopes Prize

Louis Golowich ’22 | Rose Hong ’22 | Alison Kim ’22 | Jimmy Lin ’22 | Joshua Moriarty ’22
Siva Muthupalaniappan ’22 | Yash Nair ’22 | Noah Singer ’22

David B. Mumford Undergraduate Mathematics Prize

Anne Larsen ’22

Robert Fletcher Rogers Prize

First place: Rebecca Saul ’22
Second place: Forrest Flesher ’22

Friends Prize

Shared by Raluca Vlad ’22 and Tristan Yang ’22

Herb Alexander Prize

Shared by Louis Golowich ’22 and Edward Pyne ’22

Putnam Competition

Harvard students who finished in the top 489 out of 2,975 taking the exam:
Kevin Du ’25 | Guarav M. Goel ’24 | William Y. Hu ’25 | Michael Hwang ’23 | Edis Memis ’24 | Fabio Pruneri ’22 | Eric Shen ’25 | Daniel Sheremeta ’25 | Sheldon K. Tan ’22 | Franklyn Wang ’22 | Gabriel D. Wu ’25 | Alexander L. Zhang ’25

Credits

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Cindy Jimenez | Undergraduate Program Coordinator

Irene Minder | Director of Administration and Finance

Mark Kisin | Professor of Mathematics, Director of Graduate Studies

Cliff Taubes | Professor of Mathematics, Director of Undergraduate Studies

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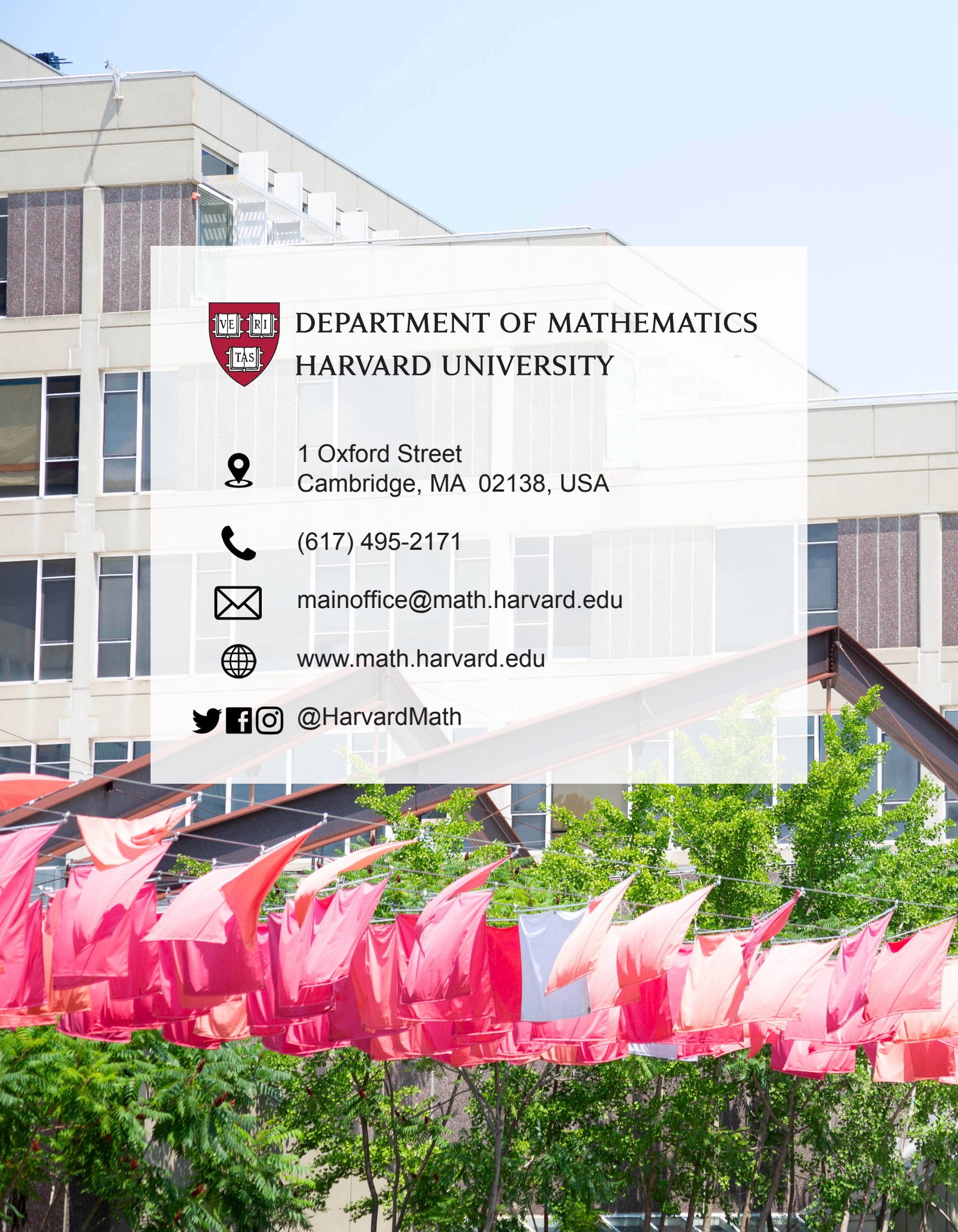

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