NEWSLETTER

MATHEMATICS

Harvard University Department of Mathematics

Academic Year 2023–2024

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 of the Harvard math department,

This has been an exciting year and the math department is full and busy. The popular common room seems always to be filled with people talking about mathematics and life. Our *Current Developments in Mathematics* conference was held in early April and featured inspirational talks by Daniel Cristofaro-Gardiner (University of Maryland), Samit Dasgupta (Duke University), Jiaoyang Huang (University of Pennsylvania), Daniel Litt (University of Toronto), and Lisa Piccirillo (MIT/University of Texas).

We welcomed Dan Freed who, in addition to assuming the position of Shiing-Shen Chern Professor of Mathematics, serves as Director of the Center of Mathematical Sciences and Applications (CMSA). He has brought exciting new activity to the CMSA such as the semester-long *Arithmetic Quantum Field Theory Program* held this Spring term.

This year also marks the retirement of Robin Gottlieb. Robin has been at Harvard for more than 40 years, during which she built and shaped our Introductory Math Program. This program is one of the gems of our department, and for a long time has been widely recognized as a model for innovative pedagogy and systems nurturing an inclusive learning environment. It is not easy to say goodbye, but she leaves us with a thriving community in introductory math, and a dream team overseeing it.

Our faculty continue to receive high recognition. This past year Hugh Woodin was elected to the National Academy of Sciences, and Melanie Matchett Wood was elected to the American Academy of Arts and Sciences.

This year we said goodbye to five of our graduate students who received their PhDs and welcomed twelve new first-year graduate students. Three Benjamin Peirce (BP) Fellows and three Postdoctoral Fellows are leaving us, and we were joined by five new BPs and two Postdoctoral Fellows.

The graduating senior class this year started their freshman year off campus with remote learning. It didn't seem to slow them down. Harvard placed 2nd in the last Putnam Competition, and the senior theses produced this year are spectacular.

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 in this past year.

With Best Wishes,

Mike Hopkins

Message From the Director of Undergraduate Studies

Cliff Taubes

William Petschek Professor of Mathematics

Director of Undergraduate Studies

Greetings!

I am writing as the Math Director of Undergraduate Studies to wish everyone an especially stress-free yet productive summer. If you have time to do some math reading, you couldn't do better than to check out some of the senior theses that were submitted this past year for honors deliberation. To my mind, this year has seen an unprecedented set of fantastic mathematical expositions (both pure and applied). I am hoping that most of them will be available in PDF format by summer at the page below:

math.harvard.edu/undergraduate/online-senior-thesis

To give you an indication of the span of the mathematics you can learn from reading them, here is a list of titles and authors:

- *The logical Modality in Gödel's ontological argument* by Aqil Azmi
- *The Atiyah-Bott-Shapiro orientation in bordism and field theory* by Jonathan Buchanan
- *The graphed model for multilayer networks* by Lauren Chen
- *A construction of exotic R^4 using Donaldson's and Freedman's theorems* by Helen Dai
- *On tournament design* by Leo Fried
- *Topology in graph theory: A new perspective on classical concepts* by Jennifer Gao
- *The joys of the Atiyah-Singer index theorem* by Dhruv Goel
- *A whirlwind tale of Whitehead torsion* by Wittmann Got
- *BGG correspondence and the construction of vector bundles on projective spaces* by Kaiying Hou
- *Order emerging from chaos: Eigenvalue density of random, Hermitian matrices* by Ben Huntsman
- *On attaching Galois representations to modular forms with application to the Ramanujan conjecture* by Hari Iyer
- *Explicit modular parametrization and Heegner points constructions* by Arav Karighattam
- *Impossibility and voting: Extending the Borda characterization theorem to non-strict voter preferences* by Jeremiah Kim
- *Moment maps in symplectic geometry* by MyeongSeo Kim
- *The analytic foundations for modularity* by Hahn Lheem
- *Finite model theory in complexity theory* by Priya Malhotra
- *Computationally speaking: The mathematical foundations of large language models and an exploration into how they tell stories* by Natalie Melas-Kyriazi
- *Beyond empirical averages: Berry-Esseen bounds in transport distances* by Edis Memes
- *The combinatorics of Markov chains* by AnaMaria Perez
- *Strategies in hypercube tic-tac-toe* by Yanni Raymond
- *Semistability and interpolation for Veronese normal bundles* by Ray Shang
- *Reconstructing viral epidemics: A random tree approach* by Ivan Specht
- *An exploration of energy functionals for knots of one and higher dimension* by Valeria Vela
- *Equivariant topology and its combinatorial applications* by Dora Woodruff
- *Information about other players in mechanism design* by Eric Yan
- *Down the rabbit hole: A game theoretic exploration of inferior equilibria* by Angelina Zhang
- *Reinforcement learning for parallel tempering of Markov chain Monte Carlo* by Daniel Zhao

A lot of mathematics to learn from these theses!

Starting July 1 and onward, Professor Laura DeMarco will be the Mathematics Director of Undergraduate Studies. Please treat her especially well and kindly! She will be helped by Wes Cain as the Assistant Director of Undergraduate Studies and by Oliver Knill. Be nice to them also!

As always, best wishes to you all.

Cliff Taubes

Dhruv Goel

‘24, Mathematics, Germanic Languages & Lits
Friends Prize Recipient

When and how did you discover your love for mathematics?

I did well in math in school, but I didn’t particularly enjoy it because it often just meant working with formulae. But then I switched schools in grade 11 and my new high school offered a class on proof-based math, which was not something I’d heard of before. I really enjoyed it, it was a whole new way of thinking. The teacher who taught that class was also excellent and cared a lot about her students. I remember the problem that she gave us that made me appreciate math so much more. It was about tiling a chessboard using straight trominoes. The solution involved using complex numbers, and I remember thinking to myself, there’s something magical going on here and I need to figure out what it is!

I also had access to an abundance of fantastic YouTube videos and channels talking about really cool math. I distinctly remember watching Mathologer, 3Blue1Brown, and Numberphile and thinking to myself, this is amazing!

What brought you to Harvard?

I got really lucky. I applied on a whim, fairly certain that I would not get in. But one thing that really attracted me to Harvard, even back then, was its uniquely strong undergraduate program. I had heard of Math 55 even back home, 6,000 miles away in Mumbai. So it was very much a dream come true when I got here, took that class, and then CA-ed it for a year and a half after that.

How did math become your concentration?

I came to Harvard knowing vaguely that I wanted to do math, but I had the privilege of taking classes with Joe Harris, Lauren Williams, and Barry Mazur in my first year. That was really eye-opening. I could see myself doing math for the rest of my life. I did explore some; I took classes in physics, astronomy, music, and languages. That exploration was successful as I’m doing a double concentration in math and Germanic studies, with a secondary concentration in music. I sing in the choirs on campus, it’s a lot of fun.

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

I’ve grown in many ways. I have learned to push myself academically, but also to think very deeply and calmly about the simplest of mathematical concepts. Because of the breadth of the course offerings, I’ve been able to explore my interests. I’m still somewhat undecided when it comes to a mathematical field of interest, but geometry is really attractive to me. Specifically algebraic geometry, because it’s very centrally located. It allows you to study whatever field of math you’re interested in. You can connect algebraic geometry to differential geometry, or to number theory on the opposite side of the spectrum, and it somehow brings everything together.

In addition, thanks to the abundance of brilliant instructors in the math department, I’ve learned how to care about both research and teaching. I’ve had excellent examples on how to be a good and effective lecturer. I think the balance of instruction and research is important. I really enjoy teaching and I’ve been a course assistant every semester that I’ve been allowed to be. I also learn a lot by teaching others.

After graduation, I’m going to the University of Cambridge for Part III of the Mathematical Tripos, a nine-month taught masters course in mathematics. After that, I’ll be going to Princeton for a PhD in math. I want to go into academia.

Tell me about your senior thesis, “The Joys of the Atiyah-Singer Index Theorem.”

There’s a fun little story behind how I stumbled on my thesis topic. Two years or so ago, I read a survey article written by Dan Freed about the Atiyah-Singer Index Theorem. I liked the communication style, and I thought the theorem itself was quite powerful and interesting. I thought I’d write my senior thesis about it. And then I heard that Dan Freed was coming to Harvard! At that point, I knew I would be writing my senior thesis on this topic, advised by Dan Freed himself.

My thesis itself is about the Atiyah-Singer Index Theorem, which relates analytic information about solutions to partial differential equations to topological information about the spaces upon which those equations are formulated. It builds a bridge between analysis and topology through geometry. That's what attracted me to this theorem, the fact that it's connected to so many different mathematical disciplines. This is something that I try to bring out in my thesis as well, that there are fantastic and beautiful connections between differential geometry, algebraic topology, algebraic geometry, and even combinatorics and number theory, that all flow out from this theorem.

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

I am honored and grateful to receive the Friends Prize. Two good friends of mine—Madison Shirazi and Benjy Firester—got it last year. And I'm close with this year's other recipient, Dora Woodruff, as well. I'm quite excited to share my work with the benefactors of the math department. This will prepare me for similar presentations I expect to give for the rest of my academic career.

Dora Woodruff

'24, Mathematics
Friends Prize Recipient

When and how did you discover your love for mathematics?

I first got interested in math in 9th grade. Before that, I had been really into creative writing and music. I had never really seen math as an artistic, expressive field before. Ninth grade is when that changed. I started taking a proof-based geometry class and that really shifted my perspective on what math is. My previous classes had been rudimentary arithmetic and plugging things into formulas. I was able to expand my interests once I could come up with my own arguments, see all the cool, different ways to approach a problem, and once I was mathematically mature enough to read things I was curious about on my own.

What brought you to Harvard?

What drew me to Harvard initially was that I felt like it was a place where I could focus on math and simultaneously also develop my other liberal arts interests. I took some linguistics and literature classes and I've been able to participate in a lot of music groups here. I play the oboe. Harvard seemed like a good place to continue to pursue these kinds of non-STEM interests.

How did math become your concentration?

I came to Harvard already convinced that I wanted to pursue pure math, and I've only gotten more enthusiastic about it here. There's a lot that I really like about it. I like the idea of doing something for the beauty of the subject primarily, and if it has applications, then that's cool. What I love about math is that it's fun, interesting, and beautiful.

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

When I was a sophomore, I took the year-long sequence in algebraic topology. The second half of that was with Mike Hopkins, who is my advisor. It was a lot of not only new material, but also a perspective on math that I hadn't seen before. That was really cool and interesting. In my last senior semester, I took a class with Lauren Williams called Topological Combinatorics which is different enough from my thesis, but still covers things that I'm really into.

The math department has definitely allowed me to grow a lot as a mathematician. I've learned so much in the last four years. Before I came here, I didn't really know much about the kind of math that's been done over the past century. One thing that's changed is that I've gotten a lot better at learning about math in general. I've developed the ability to read a research paper and fill in the background material on my own. When I started playing musical instruments, there was a point at which I went from being able to only follow exercise books to being able to pursue playing whatever I wanted. There was a kind of fluency. And I feel like I've achieved that fluency in math, too. If I want to learn about anything, I can just learn about it. My time at Harvard has made me more fluent in math.

I'm going to start a PhD at MIT next year. And I'm probably going to be focusing on combinatorics. A career in academia is the plan right now.

Tell me about your senior thesis, "Equivariant Topology and its Combinatorial Applications."

My two main areas of interest right now are combinatorics and topology. Lately, I've been really interested in the intersection of these two fields. Last summer I did a research project in topological combinatorics, relating the topological side of some objects to their combinatorics and asking questions such as what does the combinatorial structure tell us about their topological structure? I wanted to explore this exciting intersection between these two fields that I like more with my thesis.

I took a different approach from what my summer research project had been, but with a similar idea of how you can translate combinatorial information into topological information. In my thesis I was looking at problems that start off as purely combinatorial—problems about discrete objects—that can be translated into a topological problem. Specifically, by equivariant. You have some topological space, some geometric object that also has some symmetries. So you're not just studying the geometry of the space, you're also studying the symmetries that the space has.

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

I'd never heard of the Friends Prize but I've always liked giving talks about my work. It's a nice way for me to reflect on what I've learned, to synthesize it and present it clearly to someone else. I really enjoy not just reading some papers and thinking about them, but also writing my thoughts up in a way that's presentable to someone else. I find it to be a really rewarding process and I think giving the talk would be similarly rewarding.

Lauren Williams

Dwight Parker Robinson Professor of Mathematics
Sally Starling Seaver Professor at the Radcliffe Institute

Lauren Williams had received her bachelor's degree at Harvard, her PhD at MIT, and in 2006 returned to Harvard as a Benjamin Peirce Fellow. After nine years as a faculty member at UC Berkeley, she joined Harvard as a professor in 2018. Williams is an inaugural fellow of the American Mathematical Society and has received an NSF CAREER award, a Sloan fellowship, the AWM Microsoft Research Prize in algebra and number theory, and a Guggenheim fellowship, among other honors.

Discovering Mathematics

Falling in love with mathematics was a slow and steady process for Williams. "I had some excellent teachers starting in elementary school, and got a solid background in math early on," she recalled. "My parents encouraged me to explore my interests, as well." Her father was an engineer and her mother was an English teacher. They both appreciated math, even if they hadn't studied it extensively. Williams didn't know any mathematicians growing up, although she learned later that a distant relative, Carl Linderholm, was a mathematician who wrote the off-the-wall book "Mathematics Made Difficult," which is peppered with jokes about category theory.

Williams participated in a number of summer math programs through high school and developed an interest in combinatorics. Harvard didn't offer combinatorics courses at the time Williams attended but she liked her algebra and representation theory classes. As a graduate student at MIT under Richard Stanley, she decided to focus on algebraic combinatorics. "It was the aesthetic," Williams said. "I like clean answers and closed, exact formulas. I'm less drawn to theorems or proofs that involve estimates and approximations. One aesthetic I've internalized, which I think characterizes the best results, is that if the answer isn't beautiful, you asked the wrong question."

Many of Williams' results concern algebraic or combinatorial problems arising from physics, including: combinatorial formulas for the stationary distribution of the asymmetric simple exclusion process (statistical physics), structural results for soliton solutions to the KP equation (integrable systems), and the proof of the BCFW tiling conjecture for the amplituhedron (scattering amplitudes).

About Harvard

Williams loved California, where she grew up, and UC Berkeley, where she had spent much of her career. But Boston and Cambridge were where she'd made some of her closest friends, and Harvard was a smaller, private university with much smaller classes than those she had been teaching at Berkeley. "In a class of 250 students at Berkeley, most of the students felt anonymous to me," Williams shared. "At Harvard, I can get to know many of my students."

The freshman seminars she has taught, for example, are capped at 12 people. Students also have to apply to take them and so tend to be highly motivated. "It's really fun to teach freshmen who've only just arrived," Williams said. "They're so excited and thrilled to be here." She also enjoys the graduate topics classes she has taught, where the audience might include students ranging from freshmen to advanced graduate students, and even some postdocs. "It's an interesting challenge to make the class accessible to very bright undergraduates, but also to offer something for those with a lot of background," Williams said. "I start from the basics but try to touch on some topics of current research."

Outside Mathematics

As a child, Williams enjoyed writing poems for family members and friends, and had aspirations of writing a book. "I'm not sure if my eight-year-old self would be impressed with me now," Williams said. "She envisioned writing a novel, not a book about cluster algebras." Williams also plays the violin, and was part of the Harvard-Radcliffe Orchestra as an undergraduate. Nowadays she occasionally plays music with her family; both of her children play the violin. But nothing gets her out of her head quite like a good run.

Ever since the lockdown, she's been running every weekend with a college friend who lives nearby. "It doesn't matter if it's raining, snowing, or sweltering, we just brave the weather and go," Williams said. "A long run and chat with a friend who has known you since age 18 is kind of like therapy." She also runs occasionally with other friends, including her former college roommate and Harvard physics professor Jenny Hoffman, who recently set the women's world record for the fastest time running across the country. "Running with Jenny works better when she is injured," Williams joked. "I'm not at all a competitive runner but I enjoy it and it helps keep me sane."

Salim Tayou

Benjamin Peirce Fellow

Salim Tayou joined Harvard as a Benjamin Peirce Fellow (BPF) in 2020 after completing his graduate studies at Université Paris-Sud. In the fall of 2024, he will take up a position as assistant professor at Dartmouth College.

Discovering Mathematics

Growing up in Morocco, Tayou enjoyed math well enough. But he liked his Arabic and classical literature classes just as much. In middle school, he overheard his older siblings discussing more advanced math topics. “I found it fascinating,” Tayou recalled. “I would ask them questions and they would occasionally explain what they were doing.” Around this time, he began participating in math competitions. “I really enjoyed the beauty of the topic,” he said. “The way a lot of things fit together to lead to a beautiful answer.”

Tayou didn’t really think about math research as a career opportunity until university. His father and siblings were engineers, and he was considering pursuing engineering at the École Polytechnique in France. But he was also drawn to the École Normale Supérieure, known for its difficult entrance exam. “I wasn’t really thinking about it, but then I took the exam and I got in,” Tayou said. “That changed my relationship with math from solving exercises competition-style where everything is known and perfect, to discovering a whole new way of doing mathematics.” His professors were active researchers. They expected students to discover new topics on their own, and gave them the autonomy and freedom to choose their own classes. For Tayou, this was an important learning experience and the path to mathematical growth and maturity.

Developing his own research interests was heavily influenced by the people he met and their own passions. “I remember my first project was in geometric analysis and I chose that topic because my friend and I were talking about it and we both got excited,” Tayou said. “What made me settle on the topic of algebraic geometry was my advisor, who worked in that area.”

About Harvard

After eight years in Paris, Tayou entered his time as a postdoc ready to broaden his mathematical horizons. He was accepted at Harvard, at the Institute for Advanced Study at Princeton, and at the Centre de Recherches Mathématiques in Montreal. Eager to have the full experience, Tayou deferred his Harvard offer for a year and split that time between Princeton and Montreal. He arrived at Harvard in the fall of 2021. “The math activity here is amazing,” Tayou said. “In fact, a lot of what I’ve been interested in recently developed after I arrived here.”

Tayou’s research interests evolved to include Hodge loci in algebraic geometry, as well as Tate loci in arithmetic geometry using methods from Hodge theory, Shimura varieties, Arakelov theory, and homogeneous dynamics. Most recently, he’s been exploring non-abelian Hodge theory. His interest was sparked when fellow Harvard postdoc Aaron Landesman mentioned an open problem that got Tayou thinking. A year later, Tayou co-organized a learning seminar alongside other postdocs and graduate students on that same topic. He’s still working on the many questions that emerged from that learning seminar. “It’s a passion that was developed and remains interesting because of the environment here,” Tayou said.

His experiences as a junior faculty member at Harvard prepared him to continue in academia on the tenure track level. From an introductory course in linear algebra to designing his own graduate course, he got to teach classes at a number of different levels. He also organized seminars alongside senior and fellow junior faculty members, and did committee work for the graduate student admissions committee.

Outside Mathematics

Growing up, Tayou loved playing soccer and tennis. He plays piano—not very well, by his own admission—but recently he’s been learning the sintir, a traditional string instrument part of Gnawa music. This is a body of Moroccan spiritual songs and rhythms that Tayou appreciates. The music theory classes he took as a child help, as he’s completely self-taught on the sintir. While he can listen to something and try to reproduce it, he’s mostly relying on YouTube videos to get the technique down.

Message From the Director of Graduate Studies

Melanie Matchett Wood
William Caspar Graustein Professor of Mathematics
Director of Graduate Studies

Dear Friends,

This academic year, I am starting in the role of Director of Graduate Studies, a position previously held by Professor Mark Kisin for many years. I am enthusiastic about this opportunity to contribute to the continued excellence of our graduate program. We have started a new series of professional development lunches for our graduate students. Each month, a faculty member and a Benjamin Peirce Fellow lead a lunchtime conversation on a topic such as giving talks or going to conferences.

This year, we have the pleasure of guiding 54 talented graduate students, including a diverse group of 31 international scholars from 14 different countries. We have also welcomed thirteen new students this past fall, each bringing fresh perspectives and energy to our vibrant academic community.

Our graduate students have demonstrated remarkable success over the past year, securing funding not only from Harvard University and the Department of Mathematics but also earning prestigious awards from external sources. Notably, some have been honored with fellowships from the National Science Foundation (NSF), the Natural Sciences and Engineering Research Council of Canada (NSERC), the Jack Kent Cooke Foundation, and the Ezoe Memorial Recruit Foundation.

We are extremely grateful to the Putnam family for their continued contributions to our graduate program, which have been instrumental in supporting 22 of our students this year. This funding is integral to the success of graduate mathematics at Harvard.

As we approach the end of this academic year, we celebrate the achievements of five of our students who are set to graduate. They have each contributed original research across various mathematical disciplines and have secured excellent postdoctoral positions. We wish them every success as they embark on the next chapter of their professional lives.

Warm regards,

Melanie Matchett Wood

Graduate Student Spotlight

Naomi Sweeting

Naomi Sweeting is a '24 graduate of the Harvard University Department of Mathematics doctoral program. After graduation, Sweeting plans to take on a two-year postdoctoral position at Princeton University. Following that, she has accepted a position as Assistant Professor at MIT.

Naomi Sweeting can't really remember a time when she wasn't interested in math. While she has fond memories of childhood math games and her mother holds an undergraduate degree in mathematics, mostly she's just always liked it. "The idea of proving things really appealed to me," Sweeting remembered. "Once I was in sixth or seventh grade, the concept of proofs started to come up and that really fascinated me." Sweeting was involved with plenty of math enrichment activities that led to lifelong friendships such as a summer program called Canada USA Math Camp and her high school's math team. In fact, current Harvard math postdoc Aaron Landesman was her high school math team captain.

Unsurprisingly, by the time Sweeting got to the University of Chicago for her undergraduate degree, math was the obvious choice. She had other interests; Sweeting was a double major in math and history. But, from the very beginning, she knew that math was her "real thing, the rest was just a distraction," she said.

Despite this certainty, Sweeting's undergraduate experience was not very research-oriented. This was partially due to how the program at the University of Chicago was structured and partially a personal choice. "I knew that I wanted to do math and I was taking relatively advanced courses," Sweeting said. "But I didn't do undergraduate research until toward the end." Instead, she got excited about number theory by reading books like Joseph Silverman's "The Arithmetic of Elliptic Curves" and Daniel Marcus' "Number Fields." "The amazing thing about it is that you can pitch the main questions of number theory really easily to a seven-year-old," she said. "As long as you know what a prime number is, you can state all these amazing open problems in number theory and that really appealed to me, even when I was younger."

Sweeting believed that number theorists were doing "some of the most exciting stuff," as she put it, but she wasn't versed in the "fancy, modern" approach to that exciting stuff. Going to graduate school was like a whole new world opening up in front of her that she didn't know anything about, she recalled. Sweeting had applied to a number of PhD programs, but Harvard felt like a natural choice. She liked the idea that there was a large group of number theory students here that she could talk to and learn from. With the support of an NSF graduate research fellowship, she chose the Harvard Department of Mathematics in 2019.

Sweeting quickly found a close-knit community among the ten or so other graduate students under the mentorship of her advisor, Perkins Professor of Mathematics Mark Kisin. Her first semester was tumultuous but productive. Kisin frequently runs learning seminars at which he has his students give talks about different aspects of a paper. The semester Sweeting started at Harvard, his seminar was on a paper by Wei Zhang about Kolyvagin's conjecture. "All semester, Mark was saying how trying to improve on that paper would be a good project to assign to a graduate student," Sweeting said. "And I kept thinking, please, let it not be me! I had no idea what was happening in this seminar, I was totally lost. And, of course, it was me."

Once she was given the assignment, however, she threw herself into studying the subject. By the fall of her third year, she had succeeded in her task and answered Kisin's question. She also came to love the subject that had initially seemed so intimidating. Sweeting's project culminated in a paper titled "Kolyvagin's Conjecture and patched Euler systems in anticyclotomic Iwasawa theory."

"After that, I didn't really know what to do," Sweeting said. Kisin has a policy of only giving his students one problem. After that, he expects them to choose their new path on their own. "It took me a while, but eventually I ended up in the direction of Tate classes, which, while not so closely related to the first project I had done, was in the same ballpark." The resulting paper: "Tate classes and endoscopy for GSp(4) over totally real fields."

At this point, Sweetin's research interests are what she considers fairly broad. She received an NSF postdoctoral research fellowship and for the next two years she's planning to pursue multiple directions related to the work she completed during her time as a Harvard graduate student.

One of them is connected to the most recent research project she tackled about Tate classes. "If you have a Tate class, there's a prediction called the Tate conjecture that you should have an algebraic cycle," Sweeting elaborated. "I was looking at a very specific case where you can construct some Tate classes and I was trying to see if you can find the algebraic cycles." The answer, she found, was sometimes yes and sometimes no. "But the slogan is, these Tate classes are all Hodge classes." Hodge classes are a different kind of cohomological avatar of algebraic cycles. The project Sweeting was working on involved using the theta correspondence, a way of transferring automorphic forms between different groups, which has connections to both Tate classes and Hodge classes.

This kind of construction wasn't fully original to Sweeting—a similar method was developed by Atsushi Ichino and Kartik Prasanna—but there are essentially two examples of it at the moment. "I think, and some people would probably agree with me, that it should be a somewhat more general phenomenon," Sweeting said. "That's something I'd really like to get a more complete story on, because at the moment it's these two random isolated examples. And I think you can push the technique a lot farther."

First-Year Graduate Students

Andrew Burke

Undergraduate Affiliation
University of Notre Dame
Research Interests
I am interested in algebraic geometry. More specifically, I think about birational geometry and classes of singularities arising from Hodge theory.

Merrick Cai

Undergraduate Affiliation
MIT
Research Interests
I am broadly interested in geometric representation theory.

Enrico Colón

Undergraduate Affiliation
MIT
Research Interests
I am broadly interested in geometry and low-dimensional topology. Particularly, I'm interested in 4-manifold invariants and exotica.

Elia Gorokhovsky

Undergraduate Affiliation
California Institute of Technology
Research Interests
I am interested in arithmetic statistics. I particularly enjoy group-theoretic and probabilistic arguments.

Daniel Hu

Undergraduate Affiliation
Princeton University
Research Interests
I'm interested in arithmetic geometry and automorphic representation theory.

Honghao Jing

Undergraduate Affiliation
Peking University
Research Interests
I'm primarily interested in symplectic geometry, mirror symmetry and some aspects of geometric topology.

Daishi Kiyohara

Undergraduate Affiliation
MIT
Research Interests
I am interested in number theory and its relation to representation theory and algebraic geometry, with a specific focus on p-adic geometry.

Wilson Li

Undergraduate Affiliation
University of Chicago
Research Interests
I am interested in probability theory, especially models arising from mathematical physics or theoretical computer science.

August Liu

Undergraduate Affiliation
University Of Cambridge
Research Interests
I like number theory. Specifically arithmetic statistics.

Frank Lu

Undergraduate Affiliation
Princeton University
Research Interests
I am interested in arithmetic geometry.

Ollie Thakar

Undergraduate Affiliation
Princeton University
Research Interests
Low-dimensional topology and differential geometry. I like seeing gauge theory answer questions about knots, 3-manifolds, and smooth 4-manifolds.

Alan Yan

Undergraduate Affiliation
Princeton University
Research Interests
I am interested in algebraic combinatorics, representation theory, and their intersections with probability.

Runze Yu

Undergraduate Affiliation
University of California-Los Angeles
Research Interests
I’m interested in low-dimensional topology and gauge theory. Currently, I am thinking about 4-dimensional Seiberg-Witten theory.

Graduating PhD Students

Jonathan Boretsky
Advisor: Lauren Williams

Dissertation
New Perspectives on Positroids
What's Next
Six months at MPI Leipzig for a postdoc and then two-and-a-half years at McGill with a CRM postdoc.

Raúl Chavez Sarmiento
Advisor: Joe Harris

Dissertation
The Hilbert-Chow algebra of a proper surface and Grojnowski calculus
What's Next

Sung Gi Park
Advisor: Mihnea Popa

Dissertation
Additivity of Kodaira dimension and hyperbolicity for equisingular families of varieties
What's Next
Veblen Research Instructor at Princeton University and IAS.

Naomi Sweeting
Advisor: Mark Kisin

Dissertation
Tate classes and endoscopy for GSp(4) over totally real fields
What's Next
NSF postdoc at Princeton for 2 years and then a tenure track assistant professor at MIT.

Jianqiao Xia
Advisor: Zhiwei Yun (MIT)

Dissertation
Herke Categories Associated to Wildly Ramified Representations of p-adic Groups
What's Next
Postdoc at University of Chicago (Dickson Instructor).

Faculty Spotlight: Dick Gross

Professor *Emeritus*

This polaroid of Dick Gross served as his entry on the bulletin board of department faculty members, long before the specially designed and printed poster visitors of the Harvard Science Center can see today.

Dick Gross' contributions to number theory, algebraic geometry, modular forms, and group representations earned him a MacArthur Fellowship in 1986. In 1987, he received the Cole Prize of the American Mathematical Society alongside Don Zagier and Dorian M. Goldfeld for their work formulating and proving the Gross-Zagier formula, which relates the height of Heegner points with the central derivatives of the zeta function of the corresponding elliptical curves. Gross is a fellow of the American Mathematical Society and the American Academy of Arts and Sciences, as well as a member of the National Academy of Sciences and the American Philosophical Society. But for all his accomplishments and contributions, he is a perfect example of how a career in mathematics is not always a straightforward journey. We spoke with Gross about the winding road that took him from math student to math professor, and his legacy at Harvard.

If you ask Dick Gross, his life as a mathematician was kickstarted by Russia. "I was eight years old when Russia sent up Sputnik," he recalled. What followed was a huge push in math and science across the U.S. that directly benefited students like Gross who went through a public school system with stellar teachers. He was interested in math by junior high, and involved with state-level math competitions in high school. Nevertheless, his career path wasn't always a straight, well-paved road.

Gross came to Harvard as an undergraduate student convinced his academic future lay in math. But this belief was shaken after what he described as a disastrous attempt at taking the notoriously difficult Math 55 course his first year. "The other students in the classroom were simply better prepared than I was," Gross admitted. "They were coming out of the New York City and Chicago school systems, and had much more training." So he decided to take Math 21 instead, and be a physics major.

At the beginning of his second year however, Gross walked past a classroom in Sever Hall where Andrew Gleason was teaching Math 55. "I thought maybe now that I'd taken Math 21, I could understand Math 55 a little better," Gross said. "I went in and it was fantastic and beautiful." He had never seen math presented in such a way. Everything that he had been exposed to up to that point required quick solutions to straightforward problems and Gross, by his own admission, has never been the fastest mathematician. Gleason's teachings pushed students to think slowly and clearly about math, and try to find the best way to express their conclusions.

"I asked Gleason if I could take Math 55 as a physics concentrator who had passed Math 21," Gross recalled. "He said, sure you can!" So Gross did. By the end of the course, had found a life-long friend in fellow undergraduate student and eventual Harvard math professor Joe Harris, and officially switched his concentration to mathematics.

The effect Math 55 and Gleason had on Gross' life and career cannot be understated. "Many times when I finally grasped some small point throughout my math research career, I'd exclaim to myself, oh my god! That's what Andy was trying to teach us!" Gross said. "Math 55 was this big, fantastic course that you could get as much out of as you were ready to get out at the time. But you'd get even more later down the line." What he was taught was burned into his head because he had to prepare for the course and take exams, but he didn't achieve full understanding of the material until he encountered it in his own research.

This is not to say that when Gross graduated in 1971, he jumped straight into the next phase of his math career. Even after four years at Harvard, he lacked any real experience with research mathematics and wasn't sure he was ready for the rigor and focus graduate school would require of him. Gross accepted a Sheldon fellowship and studied music in Africa and Asia, but quickly found that

Hitching across Kenya in 1972.

the more he played as a profession, the less he loved it. He accepted a Marshall Scholarship and studied a combination of history and sociology at Oxford University, but didn't really enjoy that, either. Then he went on vacation to Italy with a friend, exploring Renaissance artworks through picturesque Tuscan towns.

"I distinctly remember being in Perugia and looking at these fabulous paintings by Pietro Perugino and thinking to myself, see what this guy contributed!" Gross said.

Painting was Perugino's talent. Gross knew he didn't have that gift, he didn't think he had much of a future in music, and he certainly didn't have a knack for history.

"The only talent I really had was for math," he said. "So I thought maybe I ought to explore what it would be like to do research math." He didn't want his legacy to come across as derivative. Being involved in a truly creative enterprise was deeply important to Gross.

However, while he was able to change his focus at Oxford to math, he had trouble being taken seriously as a graduate student candidate by most institutions where he applied. "I'd been away from college for three years at this point, traveling around Africa and Asia, studying history and sociology, and going to Italy," Gross said. "When I wrote my application for graduate school, every place turned me down because they didn't think I was serious." But Gross was motivated. He wrote about his plight to his old mentor, Gleason, and was able to join Harvard as a special student with the idea that if he did well his first year, he'd be officially accepted into the graduate math program. “I had the advantage over other graduate students in that I had already tried everything else,” Gross recalled. “I was very committed.”

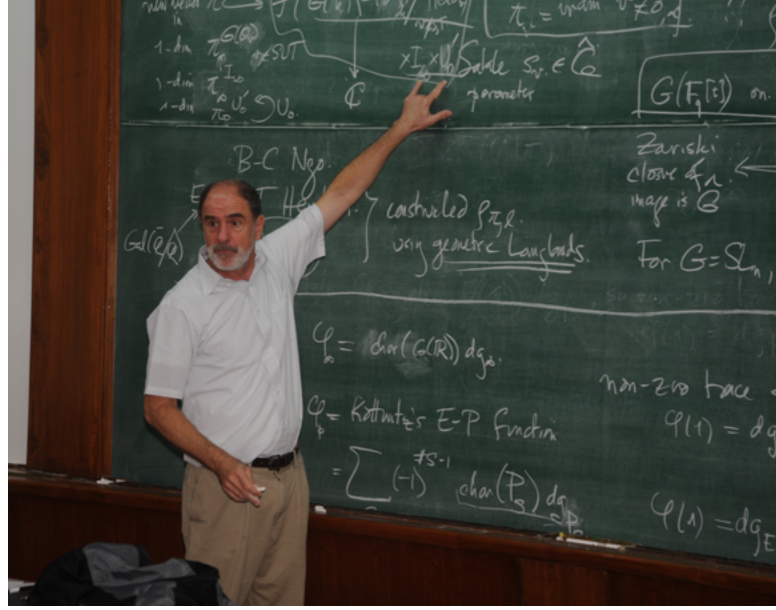
Once again at home in Harvard’s math community, he found a sense of belonging. Knowing he wanted to study number theory, Gross received what he described as “incredible instruction” from mathematicians such as John Tate and Barry Mazur. He graduated in 1978 and—after holding faculty positions at Princeton University and Brown University—returned to Harvard as a tenured professor in 1985. Thus began what amounted to over 30 years of service to the Harvard math community not just in his capacity as professor and researcher, but as department chair, Dean for Undergraduate Education and, ultimately, Dean of Harvard College.

Gross was appointed George Vasmer Leverett Professor in 1998 and department chair in 1999. The latter was his first brush with the more administrative side of Harvard and an unexpected left turn in his career. He was just finishing his chairmanship when William C. Kirby—Dean of the Faculty of Arts and Sciences (FAS) at the time—appointed Gross to lead the first review of undergraduate education in nearly 30 years. “I was very interested because over the years things had evolved into something odd and obsolete,” Gross recalled. “I thought it was a good time for change and Bill needed someone who was familiar with the sciences.”

Gross was Dean for Undergraduate Education from 2002 to 2003 and Dean of Harvard College from 2003 to 2007. In that time, he oversaw a number of programs essential to the undergraduate learning experience, including the academic concentration, the Core Curriculum, the tutorial system, the Freshman Seminar Program, study abroad, undergraduate research, and issues related to pedagogical innovation and improvement. “I had a staff of over 340 people and a budget of $250 million,” he said of his time as Dean of Harvard College. “It was completely beyond anything that I had experienced before, but I really enjoyed it. I spent four-and-a-half years doing it and I got the curriculum review passed, although it took many years off my life. But I felt that someone must have done that for me when I was an undergraduate at Harvard, so now it was my turn to do it for those kids.”

Gross’ old friend and Higgins Professor of Mathematics Joe Harris shared a memory set during those years that he felt illustrates Gross’ impact on our community. “I was walking through Harvard Yard with him,” Harris recalled. “And I was just bowled over to see that virtually all the students we encountered knew him and clearly felt a personal connection to him. It made me appreciate how rare a person he is.” According to Harriss, his friend had a light touch that he has rarely seen from others in the position. “He did an absolutely masterful job of it,” Harris said.

At the end of the day, however, Gross was happy to return to the math department as a professor. As rewarding as



Gross giving a research talk.

his other duties had been, his heart had always been in teaching; he was appropriately named a Harvard College Professor in 2011. Gross estimates that over the years he’s had more than 30 graduate students, each more interesting than the next, and each with such a strong background that all he had to do was get out of their way. The undergraduate students he taught were just as impressive. “I met people like Manjul Bhargava and Jacob Lurie,” Gross said. “And they were like sponges. No matter what I could pour out of my head, they absorbed it all.”

He felt that he was at the center of mathematics, training the next generation of world leaders in the field. Gross viewed Harvard as a leader in mathematical innovation and was conscious of his place there as he got older. While there were still a lot of questions that interested him, as the years went on he felt those questions weren’t as fundamental to the advancement of the field of mathematics as they once might have been. Gross had promised himself that he would retire at 65 to make room for younger faculty that would provide students the creative environment he felt they deserved to progress. It was also around this time that his wife, computational biologist Jill Mesirov, received an offer from the University of California San Diego (UCSD).

Gross taught his last class at Harvard in 2015 and, in 2016, the couple moved to San Diego where Mesirov became associate vice chancellor for computational health sciences and Gross taught the occasional graduate course. “When Covid hit, I decided I didn’t want to teach virtually, so I just retired fully,” Gross said. He still “noodles around,” corresponding with people, and writing the occasional paper, but that’s the extent of it. He is happy enough with his legacy of over 30 years at Harvard and can only hope his work has left a lasting impact. “I think the atmosphere of a place outlives the people who work there,” he said. “And it makes the people who come after them better.”

Harvard Math Summer REU Back for a Second Year

Making Undergraduate Math Research Accessible to a Wide Range of Mathematics Concentrators

The summer of 2023 saw the launch of a pilot summer program designed to make undergraduate math research accessible to a wide range of Harvard math concentrators. The Harvard Math Summer Research Experience for Undergraduates (REU) was a partnership between the Department of Mathematics, the Center of Mathematical Sciences and Applications (CMSA), and the Harvard College Research Program (HCRP). The program sought to make a summer mathematics research experience accessible to students who had not previously taken part in an REU, as well as students from underrepresented groups in mathematics. This year the program—supervised by Senior Lecturer Phil Matchett Wood—is returning once again supported by the math department, the CMSA, and the HCRP.

The basic eligibility requirements for the Harvard Math Summer REU cover students who:

- *Are a continuing Harvard College undergraduate in good standing, with a preference for students with mathematics as part of their concentration or planned concentration.*
- *Have completed at least 2 proof-based mathematics courses in college.*
- *Able to be in residence in Cambridge and commit to full-time work on math research from June 7 through August 10, including attending team and individual meetings, giving weekly presentations, and working independently.*
- *Willing to spend at least one week independently writing up a paper on their project after July 12.*

There are several reasons behind the need for a department-provided REU, according to Wood. One is certainty. While summer research can be a great formative experience for graduate school, opportunities are limited. Inevitably, some students might miss out. With the Harvard Math Summer REU, they have a local backup option.

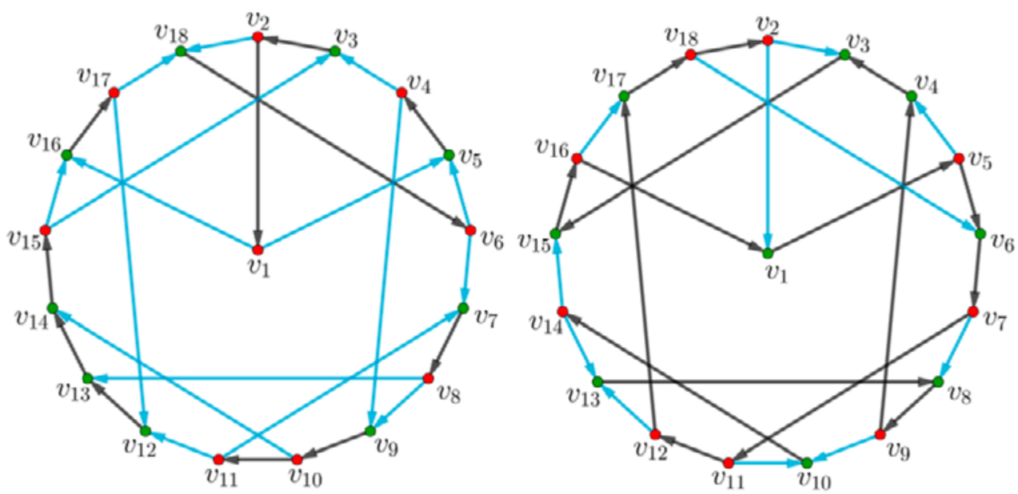
Another reason is to add clarity. The uncertainty of "will I get it, will I not" can be anxiety-inducing for students in need of a paying summer job. "This way, they can apply to outside programs, but have an internal program as a backup," Wood said. In fact, students are encouraged to accept an outside position if one is secured, for the sake of a more enriching mathematical experience.

A third reason is a recent change in the prerequisites of NSF-sponsored REUs. The NSF requires half of all participants to come from universities that don't have research opportunities for their students. "The NSF suggests those applicants be part of community colleges or smaller universities where there isn't research funding available," Wood explained. "Harvard has not qualified as one of those universities, and that means that our students are less successful than they used to be when applying to outside REUs. There are only half as many slots as there once were for them."

The 2023 pilot program was the brainchild of former Harvard Associate Senior Lecturer Dusty Grundmeier, who recruited Wood and Senior Lecturer Wes Cain. Wood and Cain oversaw a total of six student projects that summer. "The four students I supervised each produced a very nice manuscript in the summer," Wood said. "Two of them have already been submitted for publication, and the other two are really close."

This year, Wood will be the only supervisor. He's aiming for a group of four to six, and he's looking forward to applying some of the lessons of the past summer. Wood acknowledged that perhaps a bigger part of the program should be spent making sure results are properly written up. "It's a short program," he said. "But sometimes you do all the work, think everything through, and figure out what the mathematical proof should be, but don't realize that writing it all up takes a lot of time and care." He intends to encourage students who get reasonable results quickly to write up their findings earlier in the summer and submit them before the school year starts.

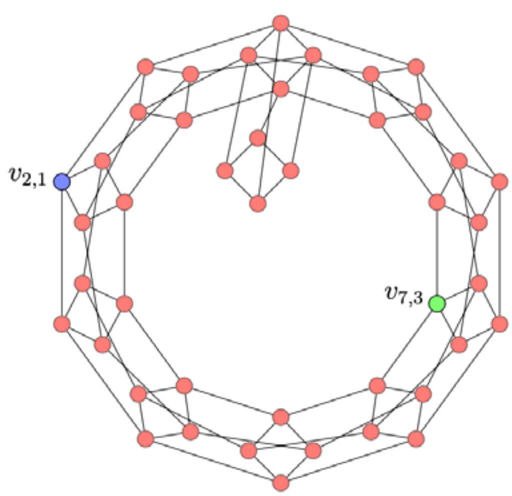
The 2024 Harvard Math Summer REU will run a Graph Theory and Combinatorics Lab investigating topics



Two orientations of a graph. If one deletes the blue arcs in each orientation, the graph remains strongly connected, and since every edge is blue in one of the two orientations, the graph has Frank number 2. From [Barat, J, and Zoltan, B. L., Australas. J. Combin., 88 (1) (2024)]. Students might build on this work during the 2024 Harvard Math Summer REU.

including dispersed graph labelings, a graph operation that causes some graphs to become Hamiltonian, a graph invariant relating to orientations and edge deletion, and questions classifying possible sets of at least four non-transitive dice. Wood himself is on the combinatorics and graph theory side of the research spectrum and thinks those areas can present good problems for undergraduates.

After all, graduate students complete a full undergraduate degree in mathematics, take two or three years of courses at the graduate level, and only then start on a research project. “That’s a lot more mathematics training than any of our undergraduates would have,” Wood said. “They’re not set up to tackle the same kind of research problem that our graduate students or a professional mathematician would necessarily tackle, except in some select areas.” According to him, graph theory presents plenty of interesting and challenging problems that don’t require a lot of background to solve.



A 3-colored graph with no 3-term arithmetic progression from: [Miller, J and Warberg, N., Australas. J. Combin., 87 (1) (2023)]. Students might build on this work during the 2024 Harvard Math Summer REU.

Graph theory also often lends itself to computer analysis. If one is looking for a graph with a specific property, one could use a computer to generate a thousand graphs and see if any of them have that property. And while that is possible in other areas of math research, it is much more challenging and tricky. Graph theory/combinatorics objects, meanwhile, are much more amenable to being generated by a computer, according to Wood.

“We hope this is the start of a long story and that we can keep this program going,” he said. “Interested potential mentors should definitely talk to me so we can grow the program.” He believes the Harvard Math Summer REU would be a valuable experience for young career math researchers considering future jobs where they might want to work with undergraduate students in research. “You can start testing if you like that now,” Wood said. And in the meantime, offer undergraduates research opportunities they might have otherwise missed.

Summer Master Class in Teaching Math Modeling for Life Sciences

Creating an Alternative to Introductory Calculus

Alan Garfield, a UCLA professor, explains the practical uses of modeling to instructors from around the country at the 2023 Master Class.

Mathematics presents an incredible way of thinking about problems that can be useful across a multitude of disciplines. Despite this, students sometimes find it challenging to see how empowering the subject can be. Brendan Kelly—a senior preceptor and Director of Introductory Mathematics at Harvard—is trying to improve students' experience in introductory math by hosting a workshop focused on math modeling for life science students.

It all started in spring 2022, when he attended a conference on transforming STEM education and heard a talk by UCLA Professor Alan Garfinkel. "Other talks focused on peripheral issues and theoretical considerations," Kelly recalled. "But Alan was placing an exciting mathematical story as the centerpiece of a change effort."

Because of the large failure rates in introductory math, math courses are seen by some as part of a "leaky pipeline" in the sciences. Thousands of students go through these courses, but a lot of them don't actually graduate with degrees in STEM fields. In response, educators across the country—including Garfinkel and Kelly—are looking for ways to pull mathematics instruction into the 21st century by teaching students through the use of real-world problems.

Garfinkel was convinced that there is a way to make students feel empowered by math rather than discouraged. He believes that doing mathematics for life science disciplines involves leveraging technological and algorithmic advancements to take a dynamical systems approach and generate deep insights into phenomena regulated by feedback, like most physiological and environmental processes. Garfinkel helped develop the Life Sciences 30 (LS30) course at UCLA over the past decade in an effort to revamp the university's calculus for life sciences courses, focusing them more strictly on math concepts and real-world biological questions, rather than on procedural rules for derivatives and integrals.

"I thought that was such a compelling way to present the problem of the leaky pipeline," Kelly said. He and Garfinkel spent the remainder of the conference discussing the barriers to doing that kind of math. Their conclusion: "A big challenge is that it's so different from the way faculty are used to teaching," Kelly said. "There would need to be some professional development for faculty to do this work."

So in the fall of 2022, Garfinkel gave a talk to Harvard faculty and the broader community about LS30 and its success among UCLA students. The response was so positive that he volunteered to return for another talk in the summer. “And I thought, if he’s doing that anyway, we should try to leverage this for other people,” Kelly said. “And that led us to the idea of having an open workshop.”

The response to the 2023 “Master Class in Teaching Math Modeling for Life Sciences” was overwhelming. Twenty-seven participants from 24 different institutions including universities, community colleges, and K-12 spaces gathered at the Harvard Science Center for a weeklong workshop. This year, that workshop is coming back with a sharper focus and clearly defined objectives.

In general, organizers have identified three main challenges. One, life sciences for the most part don’t require the content knowledge emphasized in traditional mathematics courses. Two, many mathematics faculty don’t have a lot of experience with biology or the specific mathematical requirements for effective life sciences education. And three, faculty might consequently have low confidence in being able to teach modern mathematics to life sciences majors.

The LS30 curricular materials UCLA developed, the textbook “Modeling Life,” and a suite of simulation labs and homework assignments were a response to the first challenge. The freshly renamed Stimulating Pedagogy with Authentic Research-based Knowledge for LEarning Mathematics for Biology (SPARKLE-MathBio) workshop addresses the other two challenges.

It leverages the successful LS30 curricular materials to support participants’ learning of scientific and mathematical content necessary to understand dynamical systems as models in biology. It also aims to develop participants’ modeling-specific pedagogical knowledge to effectively teach math through mathematical modeling.

SPARKLE participants engage with modeling pedagogy in three key ways. They observed Harvard preceptors implementing LS30 in Harvard’s Summer School. They reflect critically on students’ opportunities to engage in mathematics and with disciplinary practices of modeling. And finally, they discuss results from education research on the benefits of modeling for learning mathematics.

“We thought it was really critical that the workshop isn’t abstract, and that participants see the teaching and instruction of this class,” Kelly said regarding the thought process behind the design or the workshop. Seeing math department preceptors teach LS30 to high school students not only gives workshop participants the opportunity to watch ambitious pedagogy happen, it also proves that there are no calculus prerequisites. “And I think that’s a paradigm shift,” Kelly said. “It’s a very high-level class using modern mathematics, but it’s not assuming a long list of calculus prerequisites.”

The 2024 workshop will have fewer participants by design. Currently, the cap is nine so we can better develop relationships and nurture workshop outputs. It will also feature returning 2023 Master Class participants speaking about their experiences adapting and implementing LS30 at their home institutions. Among those returning participants is Samantha Kao, lecturer at the University of Arizona. The math department there has been offering “Mathematics of Biological Systems: a Calculus-Based Approach” (Math 119A) for some time and has been interested in further course development.

A room of educators at the 2023 Master Class get schooled on the rigors of mathematical modeling in the life sciences.

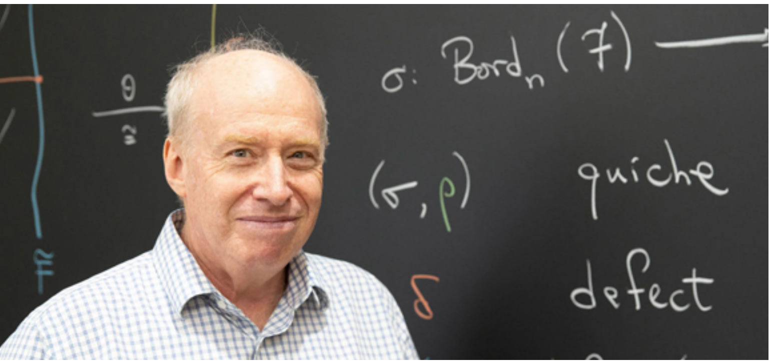
“Similar to UCLA, our course has a lecture portion and a weekly lab portion that utilizes coding,” Kao said. “Since the workshop, we have rewritten the labs with less emphasis on students learning how to code. The initial assignments introduce students to basic syntax and language that they are expected to be able to read or tweak, and the later labs focus on algorithms and models for them to interpret.” Kao’s department added an extra section of the course for fall 2024—each section capped at 99 students—which doubled enrollment. “We have maintained a full capacity and received a great response from the biology and physiology professors, who have mentioned their appreciation for this course,” Kao said.

There are big plans for some of the outputs from the SPARKLE workshop. The dream is to have similar courses that integrate calculus concepts in not just life sciences, but economics, social sciences, physical sciences, and engineering taught at colleges and high schools. Recently, Kelly even secured NSF funds to study the SPARKLE’s impacts. He is planning site visits to analyze how different departments are implementing the workshop’s teachings, what barriers they might encounter, and what needs to change in order to meet students’ needs. “We also want to figure out how to assess student learning and make sure that there are rigorous math outcomes,” Kelly said. “Exams will look different in this new course because you’re learning a way of thinking that’s very applied.”

This year’s workshop is a combined effort by Kelly and Garfinkel, alongside Texas State’s Jennifer Czocher, UCLA’s Eric Deeds, as well as Harvard’s Matthew Demers, Erica Dinkins, and Roderic Guigo Corominas. It will take place at Harvard University from June 23 to June 28.

Using Math as Bridge Within Disciplines

CMSA Welcomes New Director, a Harvard Alum Who Will Explore 'Beautiful, Deep' Interactions Between Mathematics, Science



By Anne J. Manning, Harvard Gazette. Photo courtesy of Niles Singer/Harvard Staff Photographer.

Dan Freed was as serious about perfecting his skills as a trombone player as he was about solving partial differential equations in the late 1970s. The math concentrator got special dispensation from then-Faculty Dean Raoul Bott —a famous mathematician and, later, a friend—to practice in the Dunster House senior common room, "which was my absolute favorite practice room, because the acoustics made me sound much better."

Marrying the beauty found in mathematics and art continued as a theme throughout Freed's life. And though his passion for music has never waned, it was mathematics he chose as a career.

This fall, Freed returns to Harvard as the Shiing-Shen Chern Professor of Mathematics and director of the Center of Mathematical Sciences and Applications, a multidisciplinary research center. Most recently, Freed was on the mathematics faculty at The University of Texas at Austin.

Freed took the reins of the CMSA from inaugural director Shing-Tung Yau, a longtime Harvard mathematics professor and Fields Medal recipient. Housed within the Faculty of Arts and Sciences since 2013, the center is a fusion point for mathematics, statistics, physics, and related sciences. It hosts a variety of seminars, workshops, conferences, and other events that showcase the role of mathematics in fields such as computer science and biology, besides serving as an academic home for faculty and postdoctoral researchers.

Breaking down traditional barriers within disciplines and using mathematics as a bridge between them is a fundamental element woven throughout all work at the center.

"When people outside mathematics use mathematics, they don't see the walls that we sometimes see within mathematics," Freed said. "And in the same way, when we're thinking about physics, we don't see the walls between subdisciplines that physicists sometimes see... Each of us has our base in our own field, but then when we interact, we shed light on each other's fields."

Freed is a self-described geometer who has spent many years thinking about physics, although he is not himself a physicist. His work has sought geometric answers to questions asked by theoretical physicists, be they mysteries of quantum field theory, string theory, or condensed-matter theory.

"One of the strengths of mathematics is conceptualization of structure, which consolidates many examples into an abstract framework that applies in new situations," Freed said. "There are new structures coming from physics that apply to problems in mathematics—new problems that lead to new connections that weren't anticipated. It's a beautiful, deep, two-way interaction."

One example of an unexpected cross between math and physics lines: Several years ago, Freed and collaborator Mike Hopkins, chair of the Department of Mathematics, became curious about geometric descriptions of phases of matter—solid, liquid, and gas. Different phases are characterized by differences in shape and volume.

They came up with a formula for computing all possible "invertible" phases in all dimensions and for all symmetry types. This work could carry implications for new discoveries in condensed-matter physics, which underlies various modern materials and information technology devices.

Freed hopes to continue the center's existing legacy, while encouraging new questions and collaborations in emerging fields and directions. Among them are the role of mathematics in artificial intelligence, and vice versa.

He is equally energized by his interactions with students, particularly as he teaches a new course of his own devising, the yearlong "Quantum Theory from the Geometric Viewpoint." The graduate-level course is aimed at those with a strong math background who want to engage with complex physics theories. "We will use more math than they know," he said. "But that's OK. I want them to learn to live with the feeling of not having the completely solid ground under your feet."

And maybe, in the midst of his full teaching course load and his leadership of the center, he'll find time to pick up the trombone again. But it's been a while. "That would be nice," he says.

Notable Department Events

MASTER CLASS IN
TEACHING MATH MODELING
FOR LIFE SCIENCES

Master Class in Teaching Math Modellng for Life Sciences July 9–14, 2023

A workshop designed for faculty members interested in launching a new mathematical modeling course that will serve as an alternative to introductory calculus.

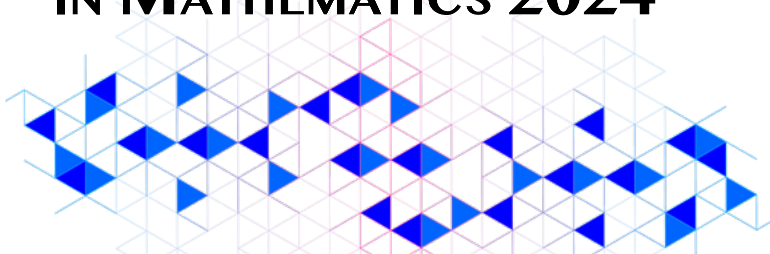
Instructors:
Alan Garfinkel | UCLA
Eric Deeds | UCLA

Jameel Al-Aidroos Mathematical Pedagogy Lecture Series Oct 2, 2023

A series that brings together speakers who share new perspectives on mathematics and pedagogy, and motivate us to reflect on our professional roles.

Speakers:
Gregory R. Goldsmith | Chapman University

CURRENT DEVELOPMENTS IN MATHEMATICS 2024



Current Developments in Mathematics, April 5–6, 2024

A conference that brings that together prominent speakers to report on recent breakthroughs in various fields of mathematics.

Speakers:
Daniel Cristofaro-Gardiner | University of Maryland
Samit Dasgupta | Duke University
Jiaoyang Huang | University of Pennsylvania
Daniel Litt | University of Toronto
Lisa Piccirillo | MIT/University of Texas

Department Honors and Awards

2024 American Academy of Arts and Sciences Elected Member

William Caspar Graustein Professor of Mathematics and Director of Graduate Studies Melanie Matchett Wood

Undergraduate Achievements

David B. Mumford Undergraduate Mathematics Prize

Shared by Dhruv Goel ‘24, Kaiying Hou ‘24, and Dora Woodruff ‘24

Herb Alexander Prize

AnaMaria Perez ‘24

Hoopes Prize

Shared by Jonathan Buchanan ‘24, Lauren Chen ‘24, Dhruv Goel ‘24, Arav Karighattam ‘24, Edis Memis ‘24, and Ivan Specht ‘24

Friends Prize

Shared by Dhruv Goel ‘24 and Dora Woodruff ‘24

Putnam Competition

Harvard undergraduate students who finished in the top 500 out of more than 3,400 students taking the exam: Radu Andrei Lecoiu ‘27 | Sebastian Attlan ‘27 | Elliot Chin ‘25 | Tanav Choudhary ‘26 | Kevin Cong ‘26 | Kevin Du ‘25 | Srihari Ganesh ‘24 | Dhruv Goel ‘24 | Andrew Gu ‘26 | William Hu ‘25 | Arav Karighattam ‘24 | Jerry Liang ‘26 | Kevin Liu ‘27 | Annabel Ma ‘27 | Edis Memis ‘24 | Jacob Paltrowitz ‘27 | Eric Shen ‘25 | Daniel Sheremeta ‘25 | Easton Singer ‘26 | Gabriel Wu ‘25 | Walden Yan ‘24 | Stephen Yang ‘27 | Sophie Zhu ‘27

Robert Fletcher Rogers Prize

First place is shared by Ivan Specht ‘24 and Daniel Sheremeta ‘25;
honorable mention to Dora Woodruff ‘24

Visit our website for the full list of honors and awards, including those announced after May 8, 2024.

Credits

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