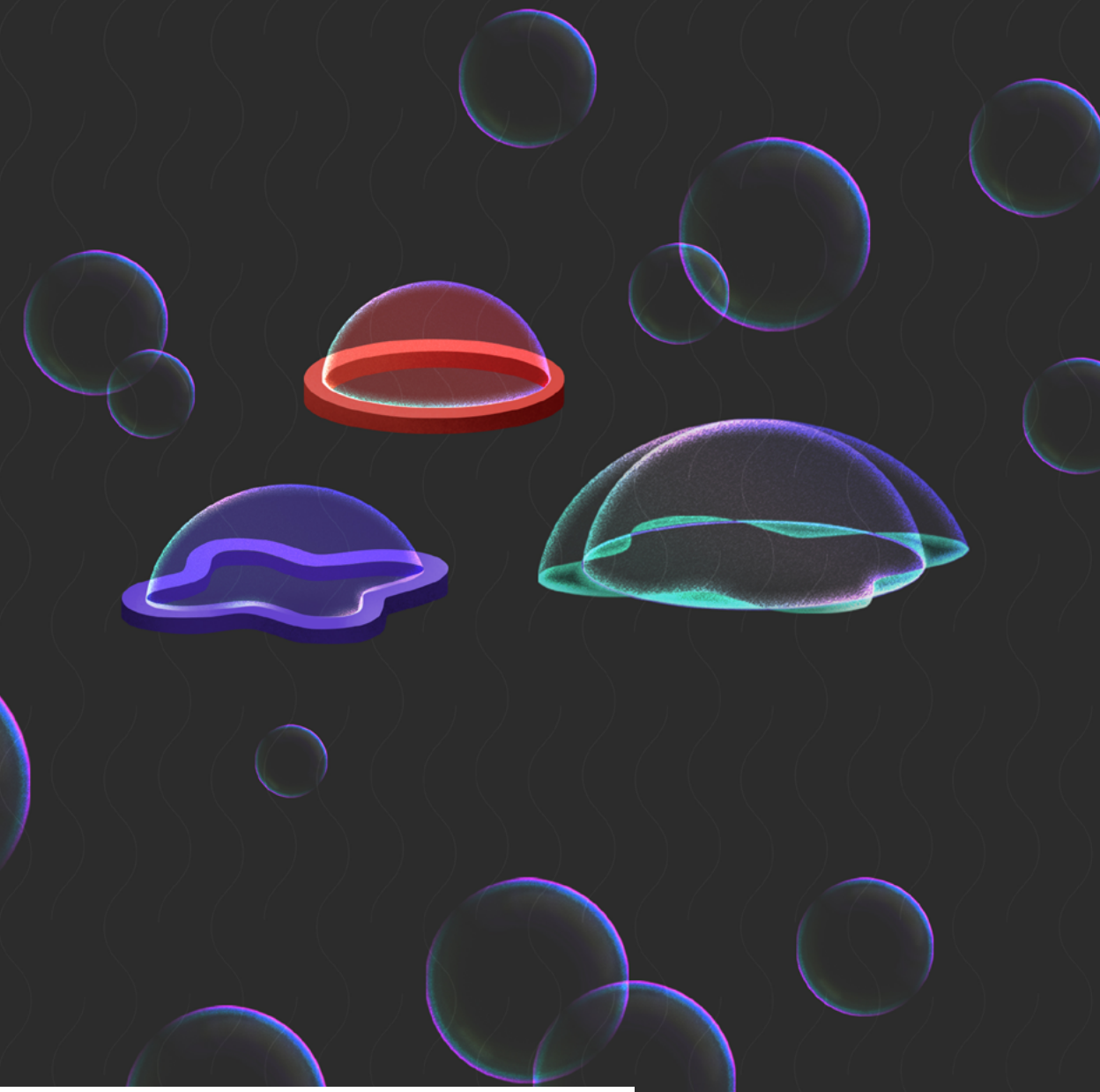
2024

CONVERGENCE



Carnegie Mellon University
Mellon College of Science
Mathematical Sciences

CONVERGENCE

The Department of Mathematical Sciences

Convergence is published yearly by the The Department of Mathematical Sciences at Carnegie Mellon University for its students, alumni and friends to inform them about the department and serve as a channel of communication for our community. Readers with comments or questions are urged to send them to ptetali@andrew.cmu.edu. The department is headed by Prasad Tetali.

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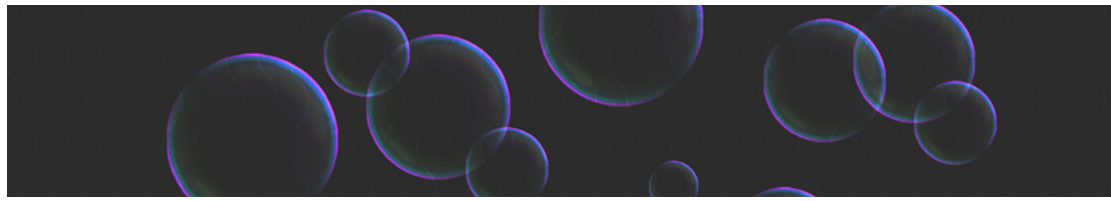
Contents



Letter from the Department Head

Dear Colleagues, Students and Friends of the Department of Mathematics,

I am filled with immense pride and gratitude for the remarkable achievements of our department in 2024. Our faculty, students and staff have demonstrated exceptional dedication, innovation and collaboration, further solidifying our position as a leader in mathematical sciences.

Our faculty have been recognized on a global stage. Irene Fonseca was elected vice president of the American Mathematical Society, Po-Shen Loh took on a new role with the International Mathematical Olympiad, Rami Grossberg was honored by Baylor University and Leif Anderson was named IAQF/Forthfield Financial Engineer of the Year.

Congratulations to Theresa Anderson and Alan Frieze for being named the Gregg Zeitlin Associate Professor of Mathematical Sciences and Hoch Orion Professor of Mathematical Sciences, respectively. We celebrated their accomplishments at an event earlier this fall.

Postdoctoral fellowships are crucial for our department, providing excellent opportunities for new Ph.D. graduates. Please check out articles about current postdocs at CMU — including Reinaldo Resende who was honored with Brazil's Prize for the best Ph.D. thesis — and the positions our students have taken elsewhere.

Our graduate students have also made us proud with their accomplishments, including hosting the 19th Graduate Student Combinatorics Conference in March.

Our educational initiatives have flourished. We supported the launch of the "Math for All" program, aimed at making advanced mathematics accessible to K-12 students in the Pittsburgh region. This initiative is designed to inspire the next generation of mathematicians. CMU also hosted the Mathematical Association of America's Mathematical Olympiad Summer Program, which showcased the talents of young mathematicians and fostered a spirit of international collaboration and camaraderie.

I am grateful to the wonderful administrative staff (IT included), whose support is highly instrumental to many of our accomplishments. I am pleased that we succeeded in getting several of them recognized with the College level staff awards this past year.

As we look ahead, we remain committed to advancing the frontiers of mathematical knowledge and fostering an inclusive and supportive environment for all members of our community. I extend my heartfelt thanks to each of you for your hard work, dedication and passion. Together, we will continue to achieve greater heights.

Prasad Tetali

Alexander M. Knaster Professor and Department Head of Mathematical Sciences

Department of Mathematical Sciences

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Department Notes

Baylor Hosts Rami Grossberg for AEC Workshop

The Department of Mathematics at Baylor University hosted a workshop on Abstract Elementary Classes (AEC) June 25-27, in honor of the 70th birthday of renowned mathematician Rami Grossberg, professor of mathematical sciences at Carnegie Mellon University. This event featured distinguished mathematicians from around the world.

Grossberg is a leading mathematician in the field of abstract elementary classes. AECs are a generalization of the notion of an elementary class in model theory, a branch of mathematical logic. Grossberg's research has advanced the understanding of AECs, including their categoricity, stability and complexity. He has advised nine Ph.D. students on AECs. Together with his students, he has shaped many of AECs in the past 30 years helping illuminate the deep connections between logic, set theory and algebra.

Organized by Grossberg's former Ph.D. students Marcos Mazari-Armida, Ph.D., of Baylor University, and Will Boney, Ph.D., of Texas State University, the conference gathered prominent researchers in AEC mathematics. Notable attendees include John Baldwin, Ph.D., University of Illinois at Chicago; Saharon Shelah, Ph.D., Hebrew University of Jerusalem; Jan Trlifaj, D.Sc., Charles University, Czech Republic; and Andrés Villaveces, Ph.D., National University of Colombia.

"We are one of the newest Logic groups in the country and to have the opportunity to host such a workshop was an honor," Mazari-Armida said.

The workshop was funded by an AMS-Simmons Travel Grant and the National Science Foundation under Grant No. DMS-2137465 and the Department of Mathematics of Baylor University.

■ *Kelly Craine*

Program Aims to Ignite K-12 Students' Relationship to Math

Being a mathematician is hard to imagine for many young students.

"When I talk with K-12 teachers, they talk about their students having a very low STEM identity, meaning that being involved in STEM or doing well in STEM isn't something that the students believe they can do," said Michael Young, associate professor of mathematical sciences and associate dean for diversity, equity and inclusion in Carnegie Mellon University's Mellon College of Science.

Young galvanized the mathematics community to offer the Ignite Students' Mathematical Identities workshop for K-12 math teachers. During the three-part workshop, which included two virtual sessions and a daylong intensive held on Feb. 18 at Carnegie Mellon, participants from 20 schools in the Pittsburgh region heard the stories of diverse voices of mathematicians and worked on the development of classroom lessons and activities to make advanced mathematics more approachable to the K-12 audience.

Multiple talents coalesced from the broad mathematics community.

Carnegie Mellon doctoral student Cat Raanes served as project coordinator. Noel Bourne and Hayley Olson, postdoctoral teaching fellows in Carnegie Mellon's Department of Mathematical Sciences, guided the grant writing efforts that led to the Grable Foundation providing a $15,000 grant to support the project for one year.

Young worked with mathematics scholars Selvi Kara and Padi Fuster, who co-founded the Meet a Mathematician website and video series and had been discussing with him how to develop lesson plans for schools. Meet a Mathematician shares the stories of mathematicians from diverse backgrounds with the aim of introducing students to role models and fostering a sense of community.

The website, www.meetamathematician.com, features more than 100 short videos of mathematicians discussing their careers, struggles and accomplishments.

"They have done amazing things," said Kara.

SPOTLIGHTING DIVERSE MATHEMATICIANS

Kara and Fuster first started recording interviews with mathematicians in 2020 after being unable to find suitable videos of women mathematicians to discuss with girl-focused math clubs.

"It was not just a problem for women but also for mathematicians of color and from marginalized groups," Kara said.

Fuster, who is a fellow in the National Science Foundation's Mathematical and Physical Sciences Ascending Postdoctoral Research Fellowship (MPS-Ascend) program, said that she and Kara share an interest in wanting to make the mathematics community more accessible.

"We heard many stories about how people didn't realize the career opportunities in math until later in life, only after they were exposed to advanced mathematics in college," Fuster said.

INSPIRING DISCUSSIONS AND CHANGE

For help connecting the Meet the Mathematician videos to the educational goals of the Ignite workshop, Young reached out to Anne Marie Marshall, a research and evaluation team leader at the University of Wisconsin-Milwaukee.

Marshall led and developed the instructional aspects of the Ignite workshops based on the National Council of Teachers of Mathematics' book series Catalyzing Change, which she said offers ways to initiate critical conversations for improving mathematics education for every student.

"The books served as a foundation for our learning as we connected to the videos," said Marshall, a co-author of the early childhood and elementary book.

Surveying the Ignite participants, Marshall noted that community-building in mathematics was a benefit reported by the teachers, along with access to new tools for the classroom.

APPLYING DIVERSE PERSPECTIVES TO EMPOWER SCHOOLS

Algebra teacher Brittany Keesecker participated in the Ignite workshop with several colleagues from Pittsburgh Science and Technology Academy.

"The in-person learning opportunity resurfaced our joy of teaching mathematics and inspired several lesson plans that were implemented at our school, in various classrooms from sixth through 12th grades," Keesecker said.

Keesecker said the workshop highlighted the importance of community, visibility and representation of various perspectives in mathematics education.

"Overall, the workshop and mathematicians added resources, inspiration and lesson plan ideas to continue propelling our professional development toward more equitable, collaborative and inclusive classrooms," Keesecker said.

Through participating in programs like this and hosting the Summer Undergraduate Applied Mathematics Institute, Carnegie Mellon's Department of Mathematical Sciences and the Mellon College of Science seek to build an inclusive and diverse community that brings together a wealth of perspectives, identities, backgrounds and cultures where every individual is treated with respect and empathy.

"When we're working with teachers, we're going to reach more students," Young said. "Being able to empower students is just good for all of us."

■ *Ann Lyon Richie*

Faculty Notes

Tetali Elected 2023 AAAS Fellow

Prasad Tetali was one of five Carnegie Mellon University faculty members elected as 2023 AAAS fellows of the American Association for the Advancement of Science (AAAS).

Tetali has been recognized for contributions to discrete mathematics and service to the scientific community.

The Alexander M. Knaster Professor and head of the Department of Mathematical Sciences, Tetali focuses his research on probability theory, discrete mathematics and approximation algorithms.

In 2021, Tetali came to Carnegie Mellon from Georgia Tech, where he had been a member of the School of Mathematics faculty since 1994 and held a joint appointment in the College of Computing since 2000. There, he was a Regents' Professor and director of the algorithms, combinatorics and optimization Ph.D. program. As an educator, he has advised many doctoral students, postdoctoral fellows and undergraduate students.

Tetali has published more than 100 research papers and given numerous invited lectures in his fields of expertise. Among his research honors, Tetali was named a fellow of both the American Mathematical Society and the Society for Industrial and Applied Mathematics.

Tetali earned his bachelor's degree from Andhra University in India, his master's degree in computer science and automation from the Indian Institute of Science and his doctoral degree from New York University's Courant Institute of Mathematical Sciences. He completed postdoctoral work at AT&T Bell Labs.

Linnea Farnsworth Photography

Fonseca Elected Vice President of American Mathematical Society

Irene Fonseca, Kavčić-Moura University Professor of Mathematics and director of the Center for Nonlinear Analysis at Carnegie Mellon University, was elected a vice president of the American Mathematical Society (AMS) for 2025–2027.

A member of the Carnegie Mellon faculty since 1987, she is an internationally respected educator and researcher in the field of applied mathematics.

"I am profoundly grateful for the opportunity to be considered for the vice president role at the AMS, especially during a time when engineering, technology, the sciences, and our society are encountering new and changing challenges," Fonseca said.

Fonseca directs Carnegie Mellon's Center for Nonlinear Analysis, which advances research and educational opportunities at the interface of mathematics, physical sciences and engineering. She develops mathematical tools to understand and predict smart materials and to improve computer vision.

In 2022, Fonseca received the International Society for the Interaction of Mechanics and Mathematics Senior Prize and delivered a keynote address. In addition, she is also a fellow of AMS, the European Academy of Sciences, and the Society for Industrial and Applied Mathematics (SIAM). She served on the committee that selects the Abel Prize, which is awarded annually to outstanding mathematicians.

In 2012, she became the second woman to be elected president of the Society for Industrial and Applied Mathematics (SIAM), one of the world's largest organizations dedicated to mathematics and computational science.

In 1997, she was bestowed knighthood in Portugal's Military Order of St. James.

"Irene Fonseca is one of our most distinguished colleagues in Mathematical Sciences commanding high visibility and international stature for several decades," said Prasad Tetali, the Alexander M. Knaster Professor and head of Carnegie Mellon's Department of Mathematical Sciences. "Her election to the vice president of the AMS is a testament to her lifelong commitment to the professional mathematics community."

■ *Heidi Opdyke*

Po-Shen Loh: An International Man of Math

On July 22, the United States team took its fifth victory in the International Mathematical Olympiad in the past 10 years.

Carnegie Mellon University has been an international center for competitive math, and its faculty fostered an environment where each year's team could prepare to show their skills to the world. Mathematical Sciences Professor Po-Shen Loh has been at the heart of it.

"If you want to change the world, it helps to be a little crazy," Loh said.

From 2013-2023, Loh served as the head coach for the U.S. team that competed at the International Mathematical Olympiad, which placed first in the world four times during that period. He also oversaw training with the Mathematical Association of America's Mathematical Olympiad Summer Program, which took place annually at Carnegie Mellon's Pittsburgh campus from 2014–2024 and brought some of the world's best high school math students together for training.

Loh, a professor in the Department of Mathematical Sciences in the Mellon College of Science, is an international evangelist for education and speaks about the need for "intellectual fearlessness," which he said is one of the key aspects of learning for long-term success. His primary work now focuses on combining his national Olympiad experience and his insights from marathon speaking tours to invent scalable solutions to uplift human intelligence and empathy, to help society thrive in the age of AI. When he took over the U.S. program, he decided to take a radical new approach to preparing mathletes for success.

"I said, 'Well, if you put me in charge we'll probably do worse because I'm not going to focus on how the students do this year. I'm more interested in maximizing the chance that I read about the students in the New York Times in 20 years,'" Loh said. "The kind of message that I sent had nothing to do with performance in the contest. It was more on the importance of having some sense of responsibility given all of these skills."

Loh's research covers concepts such as probability, combinatorics, algorithms and real-world applications of math. A recipient of the United States Presidential Early Career Award for Scientists and Engineers, he has sought to teach these subjects while conveying an enthusiasm for humanity to students. Known for this personable approach to education, he avoids emphasis on exact answers to mathematical problems in favor of creativity, exploration and human value.

Reflecting on the past decade's challenges and success, Loh said that the approach proved effective.

In 2015, Loh led the U.S. team to victory for the first time in 21 years. The team repeated its victory again in 2016, and Loh and the high school students were invited to the White House for their achievements. Loh coached the U.S. IMO team to another set of consecutive wins in 2018 and 2019.

Today, Loh takes the same approach to his work as inaugural vice president for advancement at the International Mathematical Olympiad Foundation. As a high school student, he earned a silver medal at the 1999 IMO, and understands the pressure the competition brings. He spent much of his time at the 65th International Mathematical Olympiad in Bath, United Kingdom, simply speaking with teams from around the world. The IMO took place July 11-22.

"I'm not actually here to represent one particular country anymore. My philosophy is that I like to connect the world," he said, recounting conversations with teams and individuals from Rwanda, Malaysia, Ghana, Singapore, Slovakia and others. Loh has been connecting with thousands of students worldwide for years, having delivered talks in many cities to encourage more students to embrace high-level math.

He is focused on helping alumni stay connected globally.

"Before I had left as the U.S. Math Olympiad coach, I got this idea: 'Wouldn't it be nice if we started an International Math Olympiad alumni reunion? I wonder if anyone's ever done this thing before.' And the answer was no," he said.

Loh organized the alumni reunion, which overlaps with the last two days of the International Mathematical Olympiad and goes on two days afterward. The hope, Loh says, is to facilitate real relationships.

> *"If you want to change the world, it helps to be a little crazy." — Po-Shen Loh*

"My inspiration to do this came from the great interactions I had with Carnegie Mellon's offices that worked with alumni, specifically University Advancement. Observing what interesting value can be unlocked by connecting with alumni to support — in huge ways — the mission that we do as a university. These were inspiring to me."

Another aspect of his work has stayed similar despite the change in scale between coaching U.S. students and his new role at the IMO: a drive to help people anywhere, at any stage, think outside the box to tackle big-picture problems. In 2020, his "Ask Math Anything" series gave people a chance to hear his expert opinions during a critical time.

The ability to tackle problems in this way will be more important as technology advances, and mathematical complexity with it, Loh said.

"You have to be willing to bite off a project like, 'Can we help control pandemics?' 'Can we find a way to teach enormous numbers of people how to solve problems they haven't seen before?' or 'Can we find a way to help the general public survive the rise of AI?" Loh said. "These are the kinds of things that I'm working on, and you have to have a certain level of fearlessness to start."

■ *Alexander Johnson*

DID YOU KNOW?

2016 was a banner year for competitive math. Along with coaching the U.S. high school team to a win at the International Mathematical Olympiad, Loh also coached the Carnegie Mellon team to its first-ever win at the William Lowell Putnam Competition, the premier mathematics competition for undergraduate students in North America.

Robin Neumayer Awarded NSF Career Award

Carnegie Mellon University mathematician Robin Neumayer has received a Faculty Early Career Award (CAREER) from the National Science Foundation. One of the most prestigious awards for young faculty, CAREER awards recognize and support those who exemplify the role of teacher-scholars through their outstanding research and teaching.

Neumayer, an assistant professor of mathematical sciences, received the five-year grant to work on geometric aspects of isoperimetric and Sobolev-type inequalities.

"Isoperimetric inequalities and Sobolev inequalities are ubiquitous in the mathematical fields of analysis and geometry, both as a topic of study and as tools to understand other mathematical problems," Neumayer said. "The most exciting problems are ones where a result about these inequalities has connections or applications to other parts of mathematics."

The classical isoperimetric inequality, whose study dates back to antiquity, asserts that among all surfaces that enclose a given volume, the sphere has the least surface area. This mathematical fact reflects the round shape of soap bubbles. More generally, isoperimetric inequalities, along with closely related Sobolev inequalities, relate a measurement of the "energy" (like surface area) of a shape or function to a measurement of its "size" (like volume).

Often these inequalities provide a mathematical framework to describe optimal configurations for various engineering problems and physical systems. They are also central to the mathematical fields of analysis and geometry.

Neumayer's NSF project investigates several geometric questions related to isoperimetric and Sobolev-type inequalities, including the following: if one only has measurements of a given rod's resistance to twisting forces, how much geometric information can be recovered about the shape of the rod's cross-sections?

The award also supports teaching and outreach efforts by Neumayer. As part of her activities, she will organize a workshop for women in analysis at Carnegie Mellon, and integrate research and education through minicourses, research talks and other programs.

Neumayer joined Carnegie Mellon in 2021 and was awarded the 2024 Association for Women in Mathematics Sadosky Research Prize for outstanding contributions to calculus of variations, partial differential equations and geometric analysis.

■ *Heidi Opdyke*

Michael Young Honored by Local Organizations

Michael Young, associate dean for diversity, equity and inclusion for Carnegie Mellon University's Mellon College of Science, has been named to the 2024 Men of Excellence Awards by the New Pittsburgh Courier. The award celebrates African American men from the Greater Pittsburgh area who are positively impacting the community and working diligently to make a difference.

Young was one of 50 men honored at the 2024 Men of Excellence Awards & Induction Ceremony, on Sept. 13.

"I am truly humbled and grateful for this recognition," Young said. "It reflects the collective effort of the MCS team and the support that I receive from the CMU community."

Young is an associate professor in the Department of Mathematical Sciences. His research is in discrete mathematics, specifically graph theory, combinatorics and applications to combinatorial matrix theory.

Earlier this year, The Advanced Leadership Institute and Carnegie Mellon's Tepper School of Business announced Young was part of the 2024 Executive Leadership Academy cohort. The Executive Leadership Academy provides a world-class executive education tailored to the challenges Black professionals face in the workplace. Cohort members also benefit from executive coaching, executive mentorship and peer networking.

"I believe that TALI has been a powerful engine for growth, success and community development among Pittsburgh's Black professionals, " Young said. "I'm most excited about the opportunity to network and make connections with peers and leaders from across the city. "

Young earned his Ph.D. in mathematical sciences in 2008 at Carnegie Mellon and served as an instructor in Carnegie Mellon's Summer Undergraduate Applied Mathematics Institute, which is part of the MCS Summer Scholars Program, as well as the precollege program Computer Science Scholars and the undergraduate Summer Academy for Math and Sciences. Prior to joining Carnegie Mellon as faculty, Young was an associate professor at Iowa State University.

■ *Heidi Opdyke*

Leif Andersen Named 2023 IAQF/ Northfield Financial Engineer of the Year

The International Association for Quantitative Finance (IAQF) and Northfield Information Services named Leif Andersen, the global co-head of the Quantitative Strategies & Data Group (QSDG) at Bank of America and an adjunct professor at New York University's Courant Institute for Mathematical Sciences and at Carnegie Mellon University's Department of Mathematical Sciences, as the 2023 IAQF/Northfield Financial Engineer of the Year (FEOY). The award was presented to Professor Andersen at a celebration in New York City in the spring of 2024.

"It is an exceptional honor for me to join the ranks of FEOY winners, an esteemed group of scholars and researchers who has long been a great source to me for inspiration and, in many cases, mentorship and collaboration," Andersen said.

Northfield President Dan DiBartolomeo said that the choice of Leif Andersen as the 2023 Financial Engineer of the Year is extraordinarily appropriate.

"Contributing both as an academic and a practitioner, his work stands as foundational in multiple areas including derivatives, credit risk and interest rates," DiBartolomeo said. "Most importantly, Professor Andersen's career brings the rigorous and practical perspective of an engineer, as distinct from a financial economist."

Looking toward the future, Andersen said, "As we today stand at the cusp of a revolution in AI and Data Science applications to finance, there will be many problems and challenges — technical as well as ethical — to tackle over the coming years. Thankfully, the foundation of our field is rock solid, and I look forward to the continued stewardship and guidance by IAQF and its fellows."

Besides the 2023 Financial Engineer of the Year Award, Andersen was a recipient of Risk Magazine's Quant of The Year Award in 2001 and 2018.

Math Professor, Alumnus Retires after 20 Years at CMU-Q

One of the original faculty members at Carnegie Mellon University in Qatar (CMU-Q), Marion Oliver, retired after two decades at the Qatar campus. Oliver is a teaching professor of mathematics and has taught or advised the majority of CMU-Q's graduates. CMU-Q is a Qatar Foundation partner university.

Oliver has a long history with Carnegie Mellon University. He was a graduate student at the Pittsburgh, Pennsylvania campus, earning a Ph.D. in mathematics in 1971. He continued to work at CMU until 1979, when he left for other teaching opportunities.

"When the opportunity came in 2003 to help start the Carnegie Mellon campus in Qatar, it felt like it was meant to be," Oliver said. "Carnegie Mellon has bookended my teaching career."

Oliver has served the campus in advisory roles, including several years as the first-year advisor for all new students.

"When students start university, they are inexperienced, used to being taught in a way that just stifles their creativity," Oliver said. "They go through a transformation. When they leave, they think independently, and it's a privilege to be part of that."

Michael Trick, dean of CMU-Q, recognized Oliver's contribution at a farewell event that brought together hundreds of people from the CMU-Q community, including many of Oliver's former students.

Trick mentioned how Oliver was inspired to pursue a teaching career by a high school math teacher.

"I would suggest that over the course of his 50-year career, Marion has himself become the inspiring force for thousands of students," Trick said. "I'm sure a few of them turned out to be math professors. For all of Marion's students, his thoughtful approach to teaching and problem solving was an important step in their career paths."

Trick offered his deepest appreciation for the contribution Oliver has made to education, particularly during his 20 years in Qatar.

"On behalf of all of us at CMU-Q who have had the privilege of working with you and learning from you, thank you for your kindness, your good humor and your thoughtful guidance over these many years," he said.

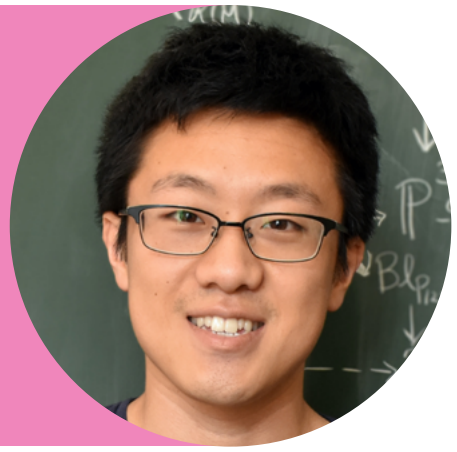
Oliver retired to his home in Atlanta.

■ *Angela Ford*

New Faculty

NICHOLAS BOFFI

Boffi joined Carnegie Mellon in August 2024 as an assistant professor in the Department of Mathematical Sciences and is an affiliated faculty member in the Machine Learning Department. He is interested in the mathematical foundations of machine learning. His research centers on generative models, and on the development of machine learning-based algorithms for the solution of high-dimensional problems in computational mathematics. Prior to joining Carnegie Mellon, he taught at the Courant Institute of Mathematical Sciences. Boffi earned his Ph.D. in applied mathematics at Harvard University in 2021.



CHRISTOPHER EUR

Eur joined Carnegie Mellon as an assistant professor in the Department of Mathematical Sciences in August 2024. Eur is interested in the interplay between combinatorics and algebraic geometry, particularly in the context of matroids and their generalizations. Prior to joining Carnegie Mellon, he was a Benjamin Peirce Fellow at Harvard University and a National Science Foundation postdoctoral Fellow at Stanford University. He earned his Ph.D. from University of California, Berkeley, in 2020.

JONATHAN SIMONE

Simone joined Carnegie Mellon as an assistant professor in the Department of Mathematical Sciences in August 2024. He is interested in low-dimensional topology and in particular, symplectic 4-manifolds, contact 3-manifolds, constructions of exotic 4-manifolds, knot theory and related problems. Prior to joining Carnegie Mellon, Simone was a visiting assistant professor at Georgia Institute of Technology and at the University of Massachusetts Amherst. He earned his Ph.D. in 2018 at the University of Virginia.

Staff Notes

Erin Davis Unifies Processes for Departmental Success

Erin Davis is at the juncture of the Department of Mathematical Sciences processes and is responsible for maintaining and improving standards. Her hands-on approach, dedication and integrated stance has made a significant impact.

She said she loves the people in the math department.

“We have wonderful leadership that has fostered a very egalitarian culture. The staff and faculty are a pleasure to work with and make coming to work every day a real joy.”

In 2024, Davis received the MCS Outstanding Achievement award for outstanding accomplishments and dedicated service. Her nominator said that Davis consistently goes beyond her job description to help members of the Department of Mathematical Sciences.

One example of this would be the 21st International Conference on Random Structures & Algorithms, which was held at Carnegie Mellon in 2023. The conference drew researchers from around the world, and major advancements in Ramsey Theory were discussed.

“It was a huge undertaking and required lots of coordination and teamwork between faculty, students and myself,” Davis said. “I enjoyed witnessing the buzz and excitement it generated among colleagues and friends.”

One part of the conference that was a highlight was The Random Run. The length of the race was the sum of two dice rolls, times 400 meters, or one time around Gesling Stadium’s track. One die was rolled right before the race began, and another when the lead runner just about finished the first set of laps.

“It was great to get everyone together on one track in the name of math,” Davis said. “I keep my bib number (85!) hanging in my office as a keepsake.”

Davis joined Carnegie Mellon in 2017, as part of Majd Sakr’s Sail() Team, a platform that offers job-focused technology courses, where she served as the liaison between the technical team of engineers and the community college faculty who used the learning management system and CMU-developed curricula.

“I spent a lot of time on calls gathering feedback and insight from the external faculty and relaying that to the CMU team to help improve the user experience. A lot of what I did involved active listening, relationship building and helping to facilitate process improvement,” Davis said. “I’ve taken all of those skills with me to Math where I’ve worked primarily with faculty, postdocs and staff to help improve processes and operations; facilitate communication with leadership; and help foster a positive, transparent and engaging culture within the department.”

Since joining the Department of Mathematical Sciences in 2022, Davis’ has been recognized for her delegation and leadership skills and has overseen a new project coordinator and an existing administrative assistant.

“Department Head Prasad Tetali and Business Manager Jeff Moreci have been incredibly supportive in helping me find different avenues where I can grow professionally,” Davis said.

■ *Heidi Opdyke*

RESEARCH FEATURE:

Geometric Inequalities

by Robin Neumayer

In the *Aeneid* (19 BC), the Roman poet Virgil tells the legend of Dido, a Phoenician princess in the 9th century B.C. After her brother assassinates her husband, Dido flees to North Africa, where a local king agrees to give her as much land as she can enclose by a single oxhide. Dido cuts the oxhide into thin strips and ties them together to form a long rope — on the tract of land she encloses within this rope, she will found the city of Carthage.

Dido is thus faced with the *isoperimetric problem*: among all curves of a given length, find the one enclosing the greatest possible area. Mathematically, the answer to this problem is expressed through the *isoperimetric inequality* in the plane, which says that the length ℓ of any curve and the area A it encloses satisfy the relationship

$$\ell^2 \geq 4\pi A \tag{1}$$

When the curve is a circle of radius $r > 0$, the squared length is $\ell^2 = (2\pi r)^2$ and the enclosed area is $A = \pi r^2$ and so the inequality (1) is an *equality* in this case. In particular, among curves with fixed length $\ell = \ell$, the isoperimetric inequality asserts that $4\pi A \geq 4\pi A$, i.e., the enclosed area is largest when the curve is a circle. So, Dido should configure her oxhide rope as a circle.

Figure 1: *Among curves of a fixed length, the circle encloses the largest area.*

Moving the story ahead by a few thousand years, in 1924, Bonneson established a *quantitative stability estimate* for the (planar) isoperimetric inequality (1): he proved that for any curve, the gap $\ell^2 - 4\pi A$ in (1) controls — in a quantitative sense — how close the curve is to being a circle. More specifically, Bonneson showed that

$$\ell^2 - 4\pi A \geq \pi^2 (R - r)^2 \tag{2}$$

where r and R are the radii of, respectively, the largest circle contained inside the region bounded by the curve, and the smallest circle containing this region. The quantity $R - r$ appearing on the right-hand side of (2) measures how much the curve deviates from a circle, measured in an L^∞ or Hausdorff sense.

Figure 2: *$R - r$ is quadratically controlled by the isoperimetric deficit of the irregular curve.*

The isoperimetric inequality holds in higher dimensions as well. For an open set $\Omega \subset \mathbb{R}^n$ with smooth boundary, let $P(\Omega)$ be the $(n-1)$-dimensional surface area of the boundary of Ω (called the perimeter of Ω) and let $|\Omega|$ denote the n-dimensional volume of Ω. The n-dimensional isoperimetric inequality says that

$$P(\Omega) \geq n|B_1|^{\frac{1}{n}}|\Omega|^{\frac{n-1}{n}} \tag{3}$$

where B_1 is a unit ball. As in the planar case, direct computation shows that equality holds if Ω is a ball B of any radius and center. In particular, among sets of a fixed volume $|\Omega| = v_*$, balls have the smallest perimeter, since (3) says that $P(\Omega) \geq P(B_*)$ where B_* is a ball with volume v_*. The spherical shape of soap bubbles is a physical manifestation of the $(n=3)$ isoperimetric inequality: due to surface tension, the soap film takes the shape of smallest surface area, subject to a fixed volume of air trapped inside.

Turning to the question of stability, in this context one asks if the gap (or "deficit") $P(\Omega) - n|B_1|^{\frac{1}{n}}|\Omega|^{\frac{n-1}{n}}$ controls a geometric quantity measuring how close Ω is to being a ball. What geometric quantity is appropriate? For $n \geq 3$, the deficit does not control the difference $R - r$ between the circumradius and inradius, even qualitatively: consider a set Ω formed by taking a unit ball and attaching to it a thin tube of length ~ 1 and radius $\sim \rho$. Then deficit is of order ρ^{n-2} (which we can make as small as we like), while $R - r$ is of order 1.

Instead, a more suitable quantity is the asymmetry $\alpha(\Omega)$, which measures the distance of Ω to the nearest ball of the same volume in an L^1 or measure sense. The asymmetry is defined by $\alpha(\Omega) = \inf_{x \in \mathbb{R}^n} \frac{|\Omega \Delta B_\rho(x)|}{|\Omega|}$, where $\rho > 0$ is chosen so that $|\Omega| = |B_\rho(x)|$ and Δ is the symmetric difference. In a 2008 Annals paper, Fusco, Maggi and Pratelli proved sharp quantitative stability for the isoperimetric inequality in terms of the asymmetry:

$$P(\Omega) - n|B_1|^{\frac{1}{n}}|\Omega|^{\frac{n-1}{n}} \geq c_n|\Omega|^{\frac{n-1}{n}}\alpha(\Omega)^2 \tag{4}$$

for a dimensional constant $c_n > 0$.

Figure 3: *The volume of the shaded region is* $\alpha(\Omega)$.

Quantitative stability estimates like (2) and (4) are important from a variational perspective because they describe how the energy associated to a given inequality grows from the set of minimizers. They also turn out to be useful tools to attack a variety of different mathematical problems. For example, the quantitive stability estimate (4) underpinned work of Knüpfer and Muratov (2014) on the liquid drop model in nuclear physics, in which they mathematically confirmed the experimentally observed fact that nuclei of small-mass atoms are spherical.

Beyond the specific example of the isoperimetric inequality, geometric inequalities are ubiquitous in analysis and geometry. Many of these inequalities stem from variational problems in physics and materials science, and/or encode important geometric information about the space where they are defined. Examples include the Wulff inequality, modeling ground states for crystalline materials; the Saint-Venant inequality, describing the resistance to twisting forces of rods with different cross-sectional shapes; and isoperimetric inequalities on Riemannian manifolds and associated geometric comparison theorems like the Levy-Gromov isoperimetric inequality, where optimal constants are related to curvature of the Riemannian manifold.

Another example is the Faber-Krahn inequality. For a bounded open set $\Omega \subset \mathbb{R}^n$, let λ_Ω be the first eigenvalue of the Dirichlet Laplacian, i.e. the smallest positive number for which there is a solution u_Ω to the eigenvalue equation $-\Delta u_\Omega = \lambda_\Omega u_\Omega$ in Ω with u_Ω vanishing on the boundary of Ω. When $n=2$, λ_Ω represents the "fundamental tone," or lowest vibrational frequency, produced by a drum with Ω-shaped drumhead. The eigenfunction u_Ω represents the corresponding vibrational mode.

The Faber-Krahn inequality says that

$$\lambda_\Omega|\Omega|^{\frac{2}{n}} \geq \lambda_{B_1}|B_1|^{\frac{2}{n}} \tag{5}$$

Equality is achieved when Ω is a ball of any radius and center. So, (5) says that in order to make a drum producing a given fundamental tone λ, a manufacturer uses the least amount of material (perhaps oxhide) for the drumhead by making a round drum. Or, from the dual perspective, (5) says that among all sets of the same volume, balls minimize λ_Ω.

Brasco, De Philippis and Velichkov (2015) proved a quantitative stability estimate in analogy to (4), showing that the deficit $\lambda_\Omega|\Omega|^{\frac{2}{n}} - \lambda_{B_1}|B_1|^{\frac{2}{n}}$ in the Faber-Krahn inequality (5) controls the square of the asymmetry $\alpha(\Omega)$. A different type of stability estimate was shown by Allen, Kriventsov, and the author (2023), in which the Faber-Krahn deficit controls the squared L^2 distance between eigenfunctions: for a dimensional constant $c_n > 0$,

$$\lambda_\Omega|\Omega|^{\frac{2}{n}} - \lambda_{B_1}|B_1|^{\frac{2}{n}} \geq c_n \inf_{x \in \mathbb{R}^n} \int_{\mathbb{R}^n} |u_\Omega - u_{B_\rho(x)}|^2 \tag{6}$$

Here the eigenfunctions u_Ω and $u_{B_\rho}(x)$ are L^2-normalized and extended by zero to be defined on all of $\mathbb{R}^n$, and $\rho > 0$ is chosen so $|B_\rho(x)| = |\Omega|$.

The quantitative estimate (6) also has applications. First, the same authors used (6) to prove a sufficient condition for a set in $\mathbb{R}^n$ to be $(n-1)$-rectifiable, that is, for it to have the structure of a C^1-submanifold in a weak sense. More recently, (6) was a key tool in Fleschler, Tolsa and Villa's proof of the higher dimensional ε^2-conjecture in geometric measure theory. Roughly speaking, this result says that a set in $\mathbb{R}^n$ has a C^1-submanifold structure at a point x if and only if the slices of the set by spheres centered at x are "flat" in a certain spectral sense at all scales.

Geometric inequalities are fundamental in analysis and geometry, both as objects of study in their own right and as tools to understand other problems. The past fifteen years or so have seen considerable advancements in the theory of quantitative stability for geometric inequalities and the field remains an active area of research today, motivated in part by wide-ranging applications.

Student & Postdoc Stories

Mathematical Sciences Conference Finds the Right Combination for Success

Carnegie Mellon University Associate Professor Michael Young considers ways his research could be applied to improve efficiency in an electrical power grid. Using techniques from theoretical graph theory his research could help determine more strategic placements of voltage measuring units on the grid.

Young's research has applications in combinatorics, an area of mathematics about counting and combining, where researchers seek out how many different combinations of something could be possible and the probability that certain combinations could occur.

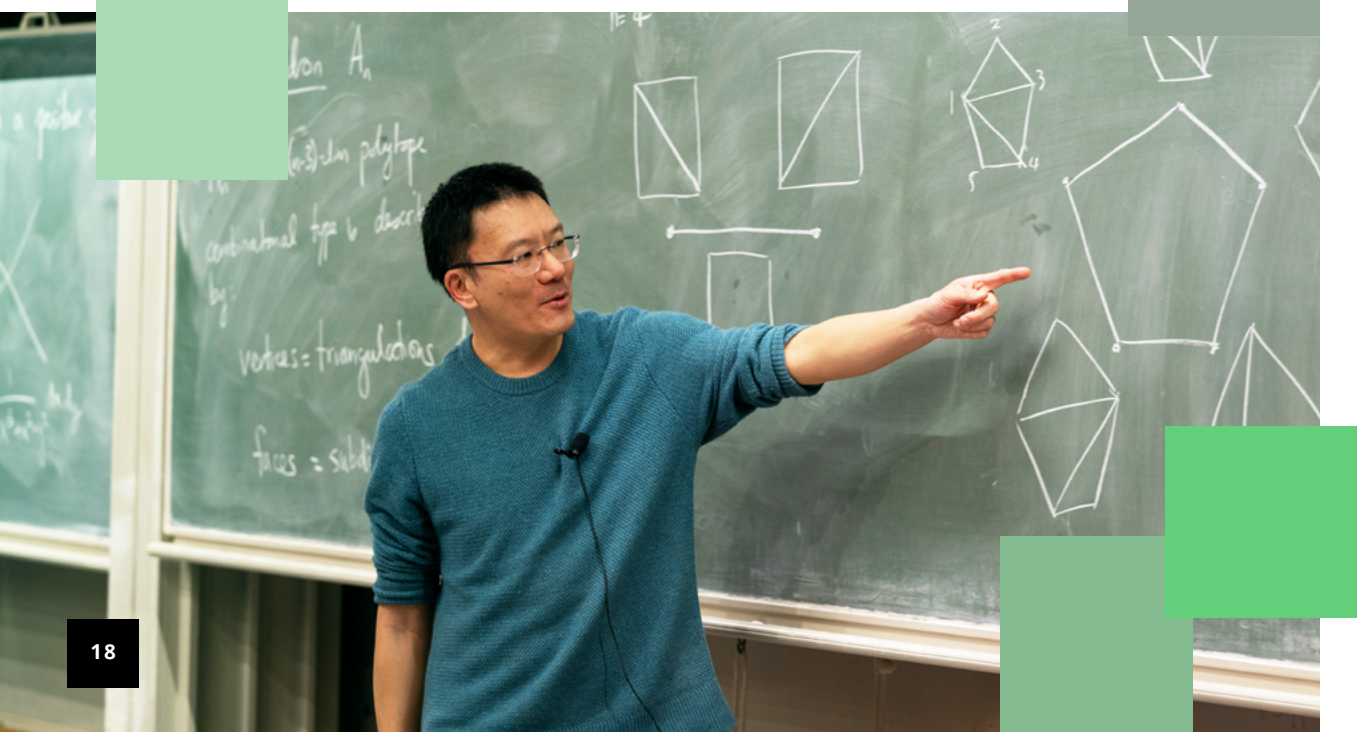
He shared his work with graduate students in mathematics who convened at Carnegie Mellon for the 19th Graduate Student Combinatorics Conference (GSCC) March 15-17.

"GSCC is a great conference for rising combinatorialists," Young said. "It was a privilege to be invited to speak and I'm immensely proud of our students for efforts they put into organizing the conference and showcasing Carnegie Mellon. Participating in this conference for graduate students is not just about spotlighting their amazing research, it's also about nurturing a vibrant community that will shape the future of discrete mathematics."

GSCC 2024 is the first time the conference took place at Carnegie Mellon, largely due to Tolson Bell leading the host application process after attending GSCC 2022 virtually. Fellow doctoral students Olha Silina and Eric Wang joined him as co-organizers.

"One of the things we called attention to in the host application was the strength of CMU in probabilistic combinatorics," Bell said. "We have seven to nine active professors who primarily study combinatorics, a well-attended weekly combinatorics seminar and an active community of Ph.D. students and postdocs."

Another selling point was CMU's interdisciplinary Ph.D. program in Algorithms, Combinatorics and Optimization (ACO), which is administered jointly by the Operations Research group in the Tepper School of Business, the Computer Science Department in the School of Computer Science and the Department of Mathematical Sciences in the Mellon College of Science.



Young was among four GSCC plenary speakers, who included Jane (Pu) Gao from the University of Waterloo, Thomas Lam from the University of Michigan and Igor Pak from the University of California, Los Angeles.

"I was always very impressed by CMU's ACO program as a group that is collaborating closely in research and supervising graduate students," Gao said.

During her presentation, Gao initiated a discussion with the 100-prisoner problem, a riddle posed by Danish computer scientist Peter Bro Milterson in 2003. In the scenario, 100 prisoners have a chance to win their freedom if they find their unique numbers inside 100 drawers without talking to each other. If they each have 50 tries, what is the probability they will all be set free?

Gao reduced the problem to the enumeration of permutations avoiding lengthy cycles and extended the discussion to the enumeration of regular graphs and beyond. She discussed various techniques to solve the riddle and similar problems. The applications of these techniques are broad and include configuration models, computing probabilities in counting graphs and estimating the probability of events using switching methods, as well as applications in related fields such as network science.

Carnegie Mellon's Boris Bukh, Alan Frieze, Po-Shen Loh and Prasad Tetali served as conference faculty advisors. Plenary speakers also met Florian Frick, associate professor in combinatorics, geometry and topology.

Three of the student speakers — Aleyah Dawkins, Quentin Dubroff and Robert Krueger — joined Carnegie Mellon in the fall as postdoctoral fellows. Dawkins received the NSF ASCEND postdoctoral fellowship and will be mentored by Young. Dubroff, who will be mentored by Tom Bohman, received a departmental fellowship, and Krueger, who is mentored by Tetali, received the NSF postdoctoral fellowship.

CMU also hosted the 2023 Random Structures and Algorithms Conference and the 2022 SIAM Conference on Discrete Mathematics.

"A decent number of attendees this year were people I had met before, either from a previous GSCC, a different combinatorics conference or other academic programs," Bell said. "It was fun for me to be the planner of a conference that I could see them enjoying."

GSCC 2024 had 120 participants, including 56 student speakers. Nine CMU doctoral students introduced speakers and moderated sessions. Bell credited his co-organizers and the team members with excellent event planning.

Staff members in Carnegie Mellon's Department of Mathematical Sciences and the Dean's Office in the Mellon College of Science provided the graduate students with logistical support. Talks took place in rooms provided by Carnegie Mellon's Heinz College of Information Systems and Public Policy.

"Tolson Bell and his team of co-organizers did a truly excellent job as judged and conveyed to me by many participants!" Tetali said, also thanking staff for support and Heinz College of Information Systems and Public Policy for event space. "The lectures I attended were all of very high quality, particularly in exposition."

Tetali, Alexander M. Knaster Professor and head of the Department of Mathematical Sciences, secured two $25,000 grants to support the conference from the National Security Agency and the National Science Foundation. Additional support for GSCC was provided by The Combinatorics Foundation and Carnegie Mellon's Department of Mathematical Sciences.

"CMU climbed to No. 3 in the graduate program rankings for discrete math and combinatorics in the last year, so bringing this annual conference to CMU is very fitting," Tetali said.

■ *Ann Lyon Richie*

Chao Earns the Guy C. Berry Graduate Research Award

Carnegie Mellon University's Ting-Wei Chao is rarely satisfied, and such a quality is perfect for discrete mathematics.

Chao, a Ph.D. candidate at the Mellon College of Science's Department of Mathematical Sciences, applied his remarkable persistence to make a meaningful contribution to extremal combinatorics, an area of mathematics that studies the counting of objects.

"Extremal means I want to find a maximum or minimum situation, such as the maximum number of certain objects," Chao said.

Chao says he enjoys theoretical work "behind the scenes" to come up with techniques to be used by the scientific audience, such as computer scientists who want to confirm their algorithms.

He first became interested in combinatorics as a high school student competing in the International Mathematical Olympiad. He studied at National Taiwan University prior to his graduate studies at Carnegie Mellon.

"For me, combinatorics is like a puzzle that is hard to solve," Chao said.

About three years into his graduate studies, Chao had co-written several papers. Professor Boris Bukh, Chao's advisor, could see that he was ready to lead his own work.

"He set himself to prove the sharp bounds for the 'joints problem,' which is the most basic result in that area," Bukh said. "It is not the kind of project that a sensible advisor would recommend to their Ph.D. student because the existing work was already very close to the sharp bounds; partial results would not have been particularly interesting. It was an all-or-nothing project.

"Ting-Wei and his collaborator did succeed, and in doing so they found unexpected connections to the 'entropy method.' The math they created is a kind of math that other mathematicians are likely to read and use. It is good math."

Bukh described an excellent Ph.D. candidate as one who has "a persistent dissatisfaction with the state of their field and a desire to right it."

"Ting-Wei might be excellent," Bukh said.

Chao is the 2024 recipient of the Guy C. Berry Graduate Research Award.

The award recognizes excellence in research by MCS graduate students and was established in 2005. Guy C. Berry, emeritus university professor of chemistry, is widely recognized as a leader in rheology and light scattering of polymers. Rheology, a branch of mechanics, is the study of those properties of materials that determine their response to mechanical force. Berry has a long history of outstanding contributions to the literature in experimental fluid physics using mechanical methods and light scattering, as well as in theoretical concepts of the rheology and thermodynamics of complex fluids. His work has advanced the study of important issues in the conformation and dynamics of macromolecules.

■ *Ann Lyon Richie*

Wellner Receives the Hugh D. Young Award

Carnegie Mellon University's Zoe Wellner has a knack for inspiring others to give mathematical sciences a try. Her teaching techniques resonate with math and non-math students alike.

"I try to break down any fear or discomfort in approaching the material," said Wellner, a doctoral candidate in the Department of Mathematical Sciences. "Students not only heal their relationship with math, but also get a lot more out of their mathematical studies and other subjects. Some of them end up wanting to do math, which is really exciting!"

She uses active learning techniques, such as engaging students in discussions, confirming their understanding as she lectures and providing revision opportunities.

"I'm usually going to be asking them, 'So what's the next step?' when I'm solving an example in class," Wellner said.

When serving as a teaching assistant (TA) for the first offering of the Introduction to Mathematical Concepts course, she said she loved making an impact on a course designed to introduce proof-based mathematics to students from any background.

Wellner served as a primary instructor for Calculus I, for which she prepared lectures, designed assignments, created the midterm exam and coordinated the TAs. At Carnegie Mellon, she connects with the Eberly Center for Teaching Excellence and Educational Innovation to observe her teaching and help her continuously improve her skills and techniques.

She also taught at Canada/USA Mathcamp, an international summer program that introduces areas of advanced mathematics to high school students.

"At Mathcamp, everybody observes each other's classes," Wellner said. "Regular observations and feedback are part of the culture and have a huge impact on my development as an instructor."

Clive Newstead, assistant teaching professor of Mathematical Sciences, described Wellner's contributions to the department and to campus as a "jaw-dropping number," which included founding a chapter of the Association of Women in Mathematics, reinstating a Graduate Student and Postdoc Seminar, serving as a mentor and advisor for the CMU Math Club, mentoring for an undergraduate research program and teaching for various programs.

"Zoe has a constant drive to bring mathematics to the masses, to advise and mentor others and to make strides to improve diversity, equity and inclusion along the way," Newstead said.

Wellner, whose focus of research is topological combinatorics, earned her Ph.D. this spring.

She is the 2024 recipient of the Hugh D. Young Award. The Young Award was established in 1995 in honor of Hugh D. Young, a professor of physics at the Mellon College of Science and is presented to one MCS Ph.D. student annually.

"She is a truly impressive educator and is a very deserving recipient of the Hugh D. Young Award," Newstead said.

■ *Ann Lyon Richie*

Market Making Game Gives Students Experience, Connections

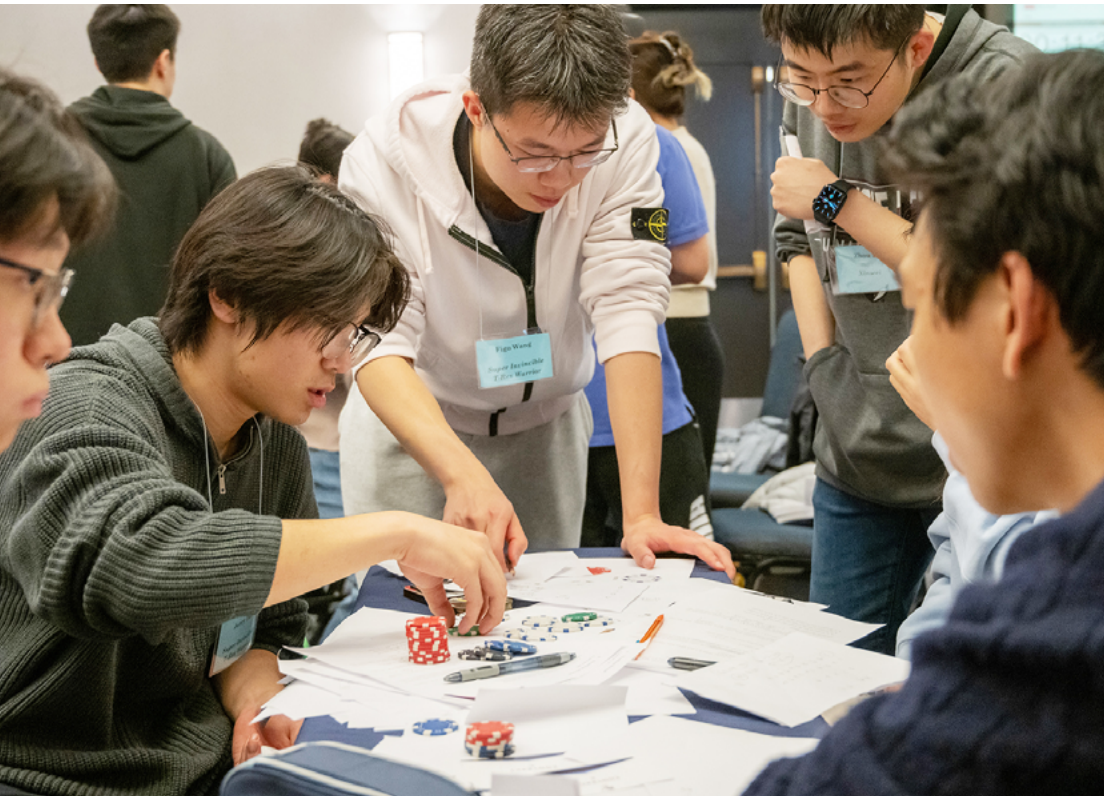
Students from across Carnegie Mellon University emulated Wall Street traders during the Quant Club's annual Market Making Game, sponsored by Optiver.

Participants solved math problems to try to determine the value of different contracts, then they traded with each other and with traders from Optiver, a proprietary trading firm and options market maker. Students were given tips from Optiver traders throughout the event, and teams were judged on their ability to estimate the value of contracts and their trading skills. Winning teams received Optiver gear and dinner with the Optiver traders.

Both undergraduate students and students from the Master of Science in Computational Finance program participated in the competition. Tze Hng Loke, a junior in computer science and the president of the Quant Club, said that Market Making Game serves as an introductory event to learn more about the field of quantitative trading.

"The event aims to test a participant's mathematical intuition as well as ability to make decisions rapidly within an extremely short period of time, skills which are quintessential for a successful quantitative trader," Loke said. "Through this event, the Quant Club hopes to develop interest in quantitative trading among the student population, and most importantly, we hope that students can have fun while trying to come up with creative strategies to trade against other teams."

■ *Kirsten Heuring*



Quantathon Competitors Harness Math Passion

On Saturday, Feb. 24, undergraduate students from across Carnegie Mellon University participated in Quantathon, an annual math competition hosted by the Quant Club and sponsored by Goldman Sachs.

Students were tasked with solving a series quantitative finance problems based on a hypothetical casino game, where a coin flip would determine whether a player would win or lose. They were asked how they could maximize winnings and what the probability of winning would be over a certain number of coin flips.

Tze Hng Loke, a junior in computer science and the president of the Quant Club, said that his past participation in Quantathon as a first-year student inspired his interest in quantitative finance.

"The problems are really interesting, and even though the problem-solving process might not have an inherent relation to finance at first glance, there are a lot of situations where you can generalize the problem to finance applications," Loke said. "It's a great way for students interested in quantitative finance to learn more about what the industry entails and what the mathematical aspects behind quantitative finance actually are."

■ *Kirsten Heuring*

Mathematician Awarded NSF Postdoctoral Fellowship

Opportunities often come from connections on a network.

Carnegie Mellon University alumnus and mathematician Felix Weilacher found an opportunity of his own through graduate studies, pursuing computations of relationships on a network.

He completed his Ph.D. at the Mellon College of Science's Department of Mathematical Sciences in May. Weilacher is a 2024 recipient of a National Science Foundation (NSF) Mathematical Sciences Postdoctoral Fellowship to work at the University of California Berkeley. The $190,000 NSF award will advance research titled, "Definable Combinatorics in Descriptive Set Theory, Computability Theory, and Beyond."

His three-year fellowship will support full-time research in his first year under sponsoring scientist Andrew Marks, followed by two years in a combined position of research and teaching at the University of California Berkeley.

Weilacher takes a logic-based perspective on combinatorics, especially graph combinatorics. In mathematics, a network is also called a graph. He looks to find connections between mathematical models that are technically very different.

"This has been a very active area of research in the past five years or so, and we can learn a lot by trying to study those connections and think about things in a more unified way," Weilacher said.

Weilacher's other network — his colleagues — have been vital to his career growth. Weilacher was drawn to Carnegie Mellon for its faculty, especially the work of Clinton Conley, associate professor of mathematical sciences.

"What's great about Felix is his versatility," Conley said. "One day he can ponder concrete coloring problems, and the next he can work on delicate set-theoretic constructions."

Courses in probabilistic combinatorics from Professors Tom Bohman and Wes Pegden also were valuable components, Weilacher said.

Ideas sparked when Anton Bernshteyn, a former postdoctoral fellow at Carnegie Mellon, joined Weilacher in attending a conference in 2022.

"One weekend of interacting at this conference gave rise to at least three collaborations that we're still working on today," Weilacher said.

■ *Ann Lyon Ritchie*

Postdoctoral Fellow Awarded Brazil's Prize for Best Ph.D. Thesis

Reinaldo Resende, a postdoctoral fellow in the Department of Mathematical Sciences at Carnegie Mellon University, has received the Professor Carlos Teobaldo Gutierrez Vidalon 2024 Award.

Resende's thesis, entitled "Some regularity results in geometric measure theory," discusses fine properties of generalized surfaces that minimize (or are stationary for) area — or more generally, anisotropic energies. These generalized surfaces encompass a broader space than the classical smooth surfaces typically studied in calculus courses and are well-suited for the analysis of geometric variational problems. The main results of Resende's thesis offer mathematical insights into understanding these minimal shapes and their, a priori, arbitrary singular behavior.

He was advised by Stefano Nardulli from the Federal University of ABC and co-advised by Camillo De Lellis from the Institute of Advanced Study in Princeton.

Organized by the Brazilian Mathematical Society (SBM) and The Institute of Mathematical and Computer Sciences (ICMC) of the University of São Paulo, in São Carlos, the Gutierrez prize is awarded annually to the best doctoral thesis in mathematics in Brazil, considering the originality and quality. The participating works must have been defended in Brazil in the academic year before the year of the award.

The recognition consists of a certificate and cash prize for the author of the awarded work, in addition to certificates for the advisor and the co-advisor.

The selection is made by a panel of experts, indicated by the Coordinating Committee of the Award, formed by the coordinator of the Graduate Program in Mathematics of the ICMC, a program advisor and a member appointed by the SBM.

The award was presented in an official ceremony at ICMC, on Sept. 23.

■ *Heidi Opdyke*

Image courtesy of NSF

CMU: A Destination for NSF Postdoctoral Fellows

The National Science Foundation (NSF) designates fewer than three dozen Mathematical Sciences Postdoctoral Research Fellowships (MSPRF) annually. Two of the 2024 award recipients will conduct research at Carnegie Mellon University.

Sumun Iyer and Robert Krueger began postdoctoral research with faculty in Carnegie Mellon's Department of Mathematical Sciences this fall. Each fellowship supports a research and training project, under the mentorship of a sponsoring scientist.

Iyer, a Ph.D. graduate from Cornell University, studies logic and will be mentored by Clinton Conley. Her project title is "Dynamics of Large Topological Groups."

"CMU has a really wonderful logic group, with lots of professors, postdocs and students, and, in my specific field of descriptive set theory, Clinton has a really wonderful group, as well," Iyer said.

Krueger, a Ph.D. graduate from the University of Illinois, Urbana-Champaign, works in combinatorics and is mentored by Prasad Tetali. His project is titled "Extremal and Probabilistic Combinatorics."

"CMU has a number of professors who work in combinatorics, as well as postdocs who work in fields adjacent to mine, talented graduate students and very strong undergraduate students, and so, all around, I'm looking forward to collaborative experiences at CMU because those kinds of opportunities are what you want to gain from postdoctoral work," Krueger said.

Tetali, Alexander M. Knaster Professor and Department Head of Mathematical Sciences, has seen an increase in research awards to the department.

"It reflects well on the department because the MSPRF host institution must show an ability to provide the best next step in the career trajectory of a new Ph.D. graduate," Tetali said.

Previously, NSF awarded the MSPRF to Carnegie Mellon postdoctoral fellow Riley Thornton, sponsored by Conley, in 2022. The NSF also awarded an ASCEND fellowship to Carnegie Mellon postdoctoral fellow Aleyah Dawkins, sponsored by Michael Young, in 2023.

"For Clinton to receive sponsorship of two NSF postdocs [Iyer and Thornton] concurrently is truly impressive," Tetali said. The Department of Mathematical Sciences also rose in rankings.

"The discrete math and combinatorics group in CMU-Math went up in the U.S. News and World Report rankings recently, from seventh to fourth in 2022 and then to third in 2023," Tetali said.

Krueger said he is influenced by Tetali's work, whose research focuses on probability theory, discrete mathematics and approximation algorithms. Tetali is a fellow of the American Association for the Advancement of Science, the American Mathematical Society and the Society for Industrial and Applied Mathematics.

"When Bob asked me to nominate him for the fellowship, it was an easy decision for me, as Bob's portfolio was very strong and the fit with CMU was also excellent," Tetali said.

Krueger's doctoral studies were advised by József Balogh, a researcher in extremal, additive and probabilistic combinatorics. As an undergraduate student, he majored in math and physics with minors in computer science and statistics at Miami University of Ohio.

"Bob also has a background in computer science and statistics, both strong fields at CMU, so it was again an easy argument to make why we would be a great next step in Bob's academic journey," Tetali said.

Another opportunity ahead for Krueger is a 2025 spring program for researchers in extremal and probabilistic combinatorics at Simons Laufer Mathematical Sciences Institute. He will take a leave to complete the semester-long program in Berkeley, California.

"I'm excited the NSF fellowship allows me to pursue this opportunity as well," Krueger said.

For Iyer, her work in logic lies in the branch of descriptive set theory, as well as related branches such as model theory and topological dynamics. In addition to her Ph.D., she has a bachelor's degree in mathematics and English from Williams College.

Iyer's recent research is on non-locally compact topological groups.

"These are basically large spaces of symmetries that exhibit phenomena that smaller spaces of symmetries do not," Iyer said.

Her fellowship will allow her to continue this research, as well as branch out, she said.

Iyer became familiar with Conley's work while working on a joint question with another mathematician. They used Borel asymptotic dimension — a tool Conley has helped to develop.

"One exciting aspect of doing a postdoc is talking to people who are in your field but different enough from the work that you have already done that you can learn a lot and explore new ideas," Iyer said.

Conley's area of work sits at the intersection of set theory, dynamics and combinatorics.

"I was familiar with Sumun's work and invited her to speak at a seminar at CMU," he said. "She gave a beautiful talk, and I think she really will bring something unique to the department."

In addition to NSF postdoctoral fellows Iyer and Thornton, Conley advised Carnegie Mellon alumnus Felix Weilacher, who is a 2024 Ph.D. graduate of the Department of Mathematical Sciences and received a 2024 NSF MSPRF award. Weilacher began his postdoctoral research this fall at the University of California, Berkeley.

Past NSF MSPRF postdoctoral fellows at Carnegie Mellon have included Joshua Ballew, sponsored by Robert Pego; Amzi Jeffs, sponsored by Florian Frick; Robert Jerrard, sponsored by Mete Soner; and Michael Kowalczyk and Russell Schwab, both sponsored by David Kinderlehrer.

Conley said that the NSF postdoctoral fellows make important contributions to the department not only in research, but also in teaching.

"Physics students, chemistry students, engineering students, and so on, all need to take math classes — so, there's a lot of teaching that needs to happen," Conley said. "University-level math is very central."

■ *Ann Lyon Ritchie*

2022 – 2023

GRADUATE STUDENT DEPARTMENT AWARDS

The Department of Mathematical Sciences began offering new internal awards for graduate students beginning in 2022. The 2024 recipients will be announced at the end of the semester during the department's holiday party and include a certificate and a cash prize.

2023 RECIPIENTS

Ting-Wei Chao
Research Award

Kian Cho and Aditya Raut
Diversity, Outreach and Mentoring Award

Allison Wang
Teaching Award

2022 RECIPIENTS

Samson Leung and Felix Weilacher
Research Award

Zoe Wellner
Diversity, Outreach and Mentoring Award

Wes Caldwel
Teaching Award

2023 – 2024

GRADUATE STUDENT PLACEMENT DESTINATIONS

Ting-Wei Chao
Massachusetts Institute of Technology
Instructor in Applied Mathematics

Wei Dai
Nankai University
Postdoctoral Associate

Pedro Marun
Czech Academy of Sciences
Postdoctoral Researcher

Mihalis Sarantis
Graz University of Technology
Postdoctoral Associate

Felix Weilacher
University of California – Berkeley
NSF Postdoctoral Research Fellow

Zoe Wellner
Arizona State University
Postdoctoral Research Fellow

Lantian Xu
Tower Research Capital
Quantitative Trader

Wentao Yang
Inner Mongolia University
Researcher (Level B2)

Danlei Zhu
Akuna Capital, LLC
Junior Quant Trader

Alumni News

Roberts Finds Ways to Serve Via Mathematics

Jonathan Roberts believes in building solid foundations and exploring mathematics.

Roberts graduated from Carnegie Mellon University in 1989 with a bachelor of science degree in applied mathematics (computer science) through the Mellon College of Science. He also studied electrical and computer engineering through the College of Engineering.

“Mathematics is more than something to apply. It is also something to enjoy,” he said.

Hoping to share his love of mathematics with the next generation, Roberts has created a series of math clubs in Washington state. His latest afterschool math program for third, fourth and fifth graders at Endeavour Elementary was oversubscribed by some 60 students. His daughter, Emily, is in fourth grade.

“We focus on fundamentals, not competition,” he said. However, at a recent math competition his students won 34 of 70 top-10 rankings among 11 competing schools.

“My mother is a teacher, as was hers. They taught me to challenge students using the Socratic method,” he said. “Using limits, my students have proved the area of a circle is πr^2. They’ve even proved the Pythagorean theorem both geometrically and algebraically.”

He consulted Carnegie Mellon faculty members to develop his approach including Department of Mathematical Sciences Head Prasad Tetali and Professors John Mackey and Po-Shen Loh.

From developing online transaction services at Transarc in the early ‘90s to helping Amazon scale to global proportions for nearly a decade to founding companies that launched Boeing into the cloud, built a global telemetry platform for John Deere and developed medical solutions, his work powers invisible services that have touched many.

“Andrew Carnegie’s ‘My heart is in the work,’ has echoed in my mind ever since CMU,” Jonathan said. “It is the best approach, whatever your work may be.”

■ *Heidi Opdyke*

Noquez Shuffles Between Math, Magic

By day, Tori Noquez is a math professor. But by night, she’s a magician. She tends to keep these two parts of herself separate — until she performed a card trick for Penn & Teller on national television. At that point, for Noquez, the cat was out of the bag.

Noquez discovered magic at age 22 when she joined her mom at an event at the invitation-only Magic Castle in Hollywood, California.

“It was just the coolest thing I’d ever seen or done,” said Noquez, who graduated from Carnegie Mellon University in 2008. “I immediately went home and signed up for their classes.”

Today, she performs at venues across the country — including headlining The Magic Castle, where she’s a member of its Academy of Magical Arts.

A professor at St. Mary’s College of California, Noquez teaches undergraduates and conducts research in category theory, a branch of formal logic. She said performing is not that different.

“A lot of math research, like magic, requires very strange and beautiful creativity, and this is the same approach I take to performing magic, where I want to think outside of reality and how I can share that with my audience,” she said.

A close-up magician, Noquez’s routine involves classic sleight-of-hand card tricks with a personal spin, and original tricks, like the one she did for “Penn & Teller: Fool Us.” She perfected her craft as she pursued a master’s degree at UCLA and a Ph.D. at the University of Illinois at Chicago.

Recently she taught her first class on magic to undergrads, and she’s given lectures at several magic clubs about the links between mathematics and various aspects of sleight-of-hand card magic. On stage, she leans into the mystique that comes with being a mathematician.

“There’s this stereotype that math is mysterious and that you must have some supernatural ability to be good at math. It kind of plays naturally to the audience that I’ve got some skill set that to them is somehow magical.”

■ *Amy Pavlak Laird*

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