UCLA

We are Mathematics

Welcome to Our Department

This year we are excited and thankful for the many accomplishments and contributions of our faculty, students and alumni, and we look forward to sharing these stories with you.

First, we are very proud of the honors bestowed on our talented faculty in recognition of their research breakthroughs. The benchmark achievements of Tim Austin, Haruzo Hida, Monica Visan and Rowan Killip, and Bill Duke were acknowledged this academic year with prizes, publications and special events.

Tim Austin was awarded the 2020 New Horizons in Mathematics Prize for his multiple contributions to ergodic theory, and in particular, for his solution to the weak Pinsker conjecture. Tim's work provides the building blocks for a better understanding of mathematical descriptions of random change. His research has been described by some as "one of the most sweeping results in mathematics in recent years," impacting several related fields, including theoretical probability, mathematical statistical mechanics and theoretical computer science.

Haruzo Hida received the AMS 2019 Leroy P. Steele Prize for Seminal Contribution to Research in recognition of his groundbreaking discovery in the early 1980s that ordinary cusp forms occur in p-adic analytic families. This breakthrough led to his theory of p-adic Hecke algebras. Haruzo's research changed the way the subject is viewed and has found deep applications in the arithmetic theory of automorphic forms.

Monica Visan and Rowan Killip, whose research focuses on dispersive partial differential equations (PDEs), developed a new method of general applicability for the study of low-regularity well-posedness problems for integrable PDEs. Specifically, they found the sharp regularity for well-posedness of the Korteweg-de Vries (KdV) equation. So far, these results for the KdV equation had only been available for specific periodic data.

Bill Duke was honored on his 61st birthday with a conference to celebrate his fundamental contributions to the arithmetic theory of modular forms. He is regarded as both a pioneer and an expert in this field, and his work has provided the basis for many mathematicians in their own research. Hosted by the Forschungsinstitut für Mathematik in Zurich, the conference brought together 200 mathematicians from around the world.

I am saddened to include in this issue an *in memoriam* piece for one of our dearest faculty members, Professor Emeritus Veeravalli Seshadri (Raja) Varadarajan. The breadth of his impact on mathematics is significant – the AMS identifies 22 fields to which he contributed over his 49-year career. In addition to prodigious achievements in teaching and publishing, Raja was highly productive in research, motivated by a particular desire to understand the role of symmetry in mathematics and physics, especially the theory of representations of Lie groups and their applications to quantum mechanics and quantum field theory. Adding to this considerable academic legacy, Raja, with his wife Veda, have gifted the Department with $1 million to establish the Ramanujan Visiting Professorship, honoring the renowned Indian mathematician. The gift underscores Raja's commitment to the international tradition of distinguished visiting lecturers.

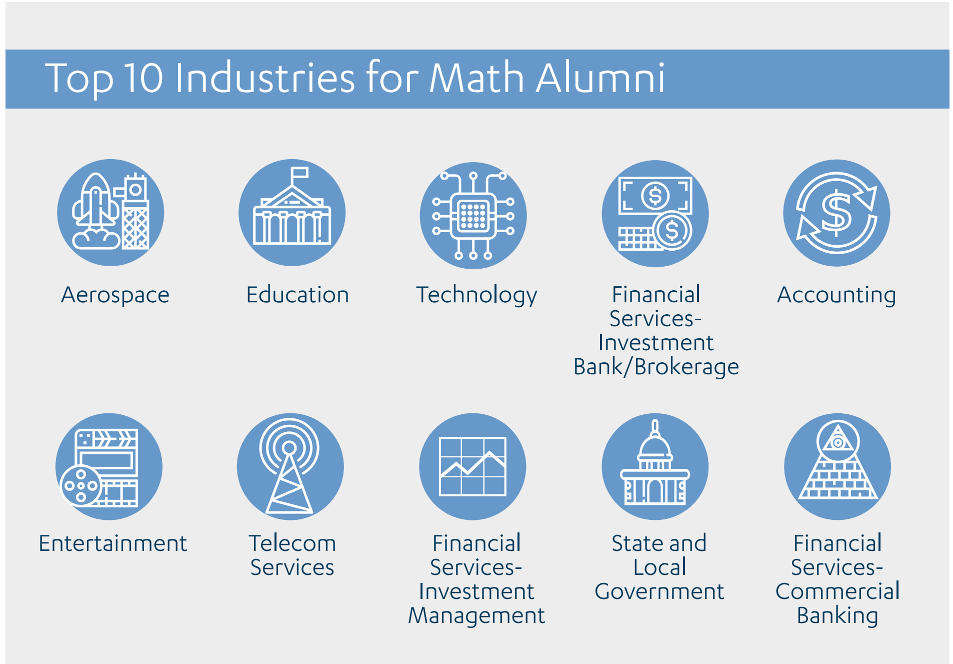
Of particular significance to the Department and the university this year is the unique and lasting philanthropy of alumnus Kirk Dunn ('83). His $1 million gift, matched by the Division of Physical Sciences, will establish an innovative new undergraduate degree and endowed chair in data theory. Kirk's generosity derives from his belief that making a place for data science in today's academic environment is crucial to its development, and it aligns with his conviction that UCLA is the best university to lead this new field into the future. The Dunn Family Endowed Chair in Data Theory will be

Magazine!

held by an eminent researcher in the field. The data science major will be a joint endeavor by the departments of mathematics and statistics. By providing a rigorous introduction to data theory, students will be prepared for graduate studies in a related field or as technical leaders in data science. This opportunity has come at an optimal time for this still-developing field to emerge as an inclusive space. One of Kirk's goals and an integral part of the data theory major is to establish, at the outset, an environment in which student diversity is nurtured.

The Department's drive to build mathematical competence across our communities is core to our academic mission. Underpinning this drive is a decades-long investment in K-12 education through a number of far-reaching programs. We offer an undergraduate mathematics teaching major, which produces highly qualified middle and high school teachers, and we continue to support this set of educators through a dedicated cadre of faculty and staff who provide advanced training, tools and guidance to the K-12 community through continuing education. Our faculty and staff also consult on state and national education projects and participate in grants that impact public schools. We have sponsored the Mathematics Diagnostics Testing Project since 1978 (UCLA is one of eight statewide sites), and we now serve over 2,000 teachers and 500 schools across Los Angeles and Ventura counties each year. In 2007, we consolidated all of our K-12 programs within the newly established UCLA Curtis Center, and an endowment was subsequently created to continue and expand the work. This year, I am proud to announce that the endowment is close to reaching the $1 million mark. The UCLA Dean of Physical Sciences has pledged to match any amount donated to this endowment through the end of 2019.

Recognizing that mathematics is becoming an increasingly collaborative discipline, our students are growing in their awareness of the power of teams in life and in study. The accompanying graphic shows the broad range



of industries that draw upon the skills and knowledge of math majors, coincidentally demonstrating the important role that collaboration plays in modern working life. Our Department's Undergraduate Mathematics Students' Association (UMSA) helps students build and utilize such teamwork early in their careers, offering both structured and informal gatherings and mentoring. UMSA's highly successful efforts to bring undergraduate students together include an annual research showcase that provides a forum for undergrads to present and share their own research to an audience of peers; informal professor talks, which give students an opportunity to meet and hear math professors in an intimate and casual setting; a mentoring program, which matches first-year math students with higher-level undergrads; and a career fair organized every fall with companies that have a track record in recruiting math undergrads. New this year is a quarterly event to help students explore and plan their math curriculum for the coming quarter.

Highlighting our student news this year is the winning entry in the NSF 2019 We are Mathematics Video Competition by the UCLA Myco-Fluidics Laboratory. Led by Marcus Roper, students in "Roper's Lab," as it is informally known, investigate cell biology and biomechanics across a broad range of problems involving math, fluid dynamics and fungal biology. The winning video, titled "MycoFluidics: The Math of Fungal Adaptation," presents mathematical models that demonstrate how nature builds efficient biological highways.

Last but not least, I am extremely pleased and proud to announce that the UCLA Putnam team ranked third out of 568 institutions in the 79th William Lowell Putnam Mathematical Competition. This is the best result in UCLA's recent history, matching team performances in 1968 and 2012. A total of 42 UCLA students participated in the competition, several winning individual prizes. This year, longtime Putnam coach Ciprian Manolescu received the Department's Distinguished Service Award for his many years of guidance and support of the team.

In closing, I hope you enjoy this year's math publication as we move into a new academic term. We appreciate the enthusiasm and contributions of our faculty, staff, students and alumni who make us one of the preeminent mathematics departments in the country!

Mario Bonk
Professor and Chair
UCLA Department of Mathematics

THE ART OF PROBLEM SOLVING

The Weak Pinsker Conjecture

Tim Austin was awarded the 2020 New Horizons in Mathematics Prize for his multiple contributions to ergodic theory, most notably the solution of the weak Pinsker conjecture. The prize, administered by the Breakthrough Prize Foundation and its founding sponsors, awards each of the year's 12 recipients $100,000 in honor of an early career achievement in physics and math.

Tim Austin first encountered ergodic theory as an undergraduate and became more involved with it as a doctoral student at UCLA; his thesis focused on the interaction between ergodic theory and additive combinatorics. His graduate advisor, Terry Tao, was actively involved in the subject and encouraged him to make mistakes and pursue instructive dead-ends, although it was a frustrating process for Tim, at times.

In the years following his doctorate in 2010, Tim was drawn to the weak Pinsker conjecture. Proposed by Jean-Paul Thouvenot in 1977, it was left as one of the main open problems in ergodic theory. Thouvenot struggled to find the missing ingredient – a mathematical function with very specific properties. At one point, shortly after graduating, Tim thought he was sure he knew how to construct a counterexample, that is, to disprove the conjecture. To his dismay, he found a mistake in his almost complete construction. This disappointment led to a period when he worked on the problem for months at a time, with breaks for other projects. He often feared that the solution to the weak Pinsker conjecture was beyond him. Reluctant to give up, Tim continued to pursue several possibilities, and finally, to his relief, a promising one showed up.

Tim Austin

In 2017, nearly seven years later, the main component fell into place. Suddenly, a once very complicated problem seemed quite simple and intuitive after all. Says Tim, "It took me some years to embrace this stage of problem solving, but now it's my favorite. And finally, I can enjoy a feeling of completion – before I get pulled into working on the next thing."

Dynamical systems describe the time dependence of specific points in geometrical or abstract spaces. Examples include the swinging of a clock pendulum and the movement of air around a room. Mathematical models try to understand this process and answer basic questions, for instance: What future states follow from the current state? Can dynamical systems be broken down into random or deterministic elements? In what ways can the evolution of the current state be unpredictable?

Tim's work provides the building blocks for a better understanding of this last issue, mathematical descriptions of random change. He showed that a dynamical system has within it a certain blend of chance and determinism: this is the weak Pinsker property. However, his result applies to all ergodic stationary processes, meaning that the random process will not change its statistical properties with time, and its statistical properties can be deduced from a single, sufficiently long-term sample of the process. Thus, the significance of the weak Pinsker property is that it imposes a basic structure on a wide range of dynamical systems.

Tim's early work on weak Pinsker revolved around examining known positive examples and trying to discern some general pattern in their behavior. With a lot of good examples already available, it remained difficult to find a pattern to tie everything together. Tim looked for a procedure for decomposing a joint distribution of many random variables into relatively few pieces that had something called "a measure concentration inequality." Tim discovered a way to quantify the "quality" that increased fast enough towards an optimum, implying that the procedure would give sufficiently good pieces fairly quickly.

Described by some as "one of the most sweeping results in mathematics in recent years," Tim is quick to point out that the importance or unimportance of a result can take many years to become clear. For now, the result may impact several other fields, including theoretical probability, mathematical statistical mechanics and theoretical computer science. Lasting implications may descend from developing similar methods in these fields, that is, finding a global structure in the joint behavior of very large collections of random quantities, even if those quantities influence each other in strong and complex ways.

Tim will receive the 2020 New Horizons Prize, in honor of his groundbreaking work in ergodic theory, at the eighth annual Breakthrough Prize gala awards ceremony, broadcast live on the National Geographic television network.

The Korteweg-de Vries (KdV) Equation

UCLA mathematicians Monica Visan and Rowan Killip have developed a new method of general applicability for the study of low-regularity well-posedness for integrable PDE. Their results are documented in the paper, "KdV is Well-Posed in H-1," which was recently published in *Annals of Mathematics*.

The KdV equation is a mathematical model for the movement of water waves. Derived by Korteweg and de Vries more than a century ago, it is also notable as the prototypical example of an exactly solvable model. However, optimal well-posedness results for KdV have only been available for periodic data, using techniques developed in the integrable-systems community. Despite intensive effort, such results remained elusive for the partial differential equation (PDE) community. Moreover the problem of treating data that decayed at infinity (as opposed to being periodic) has been a thorn in the side of both communities for a long time.

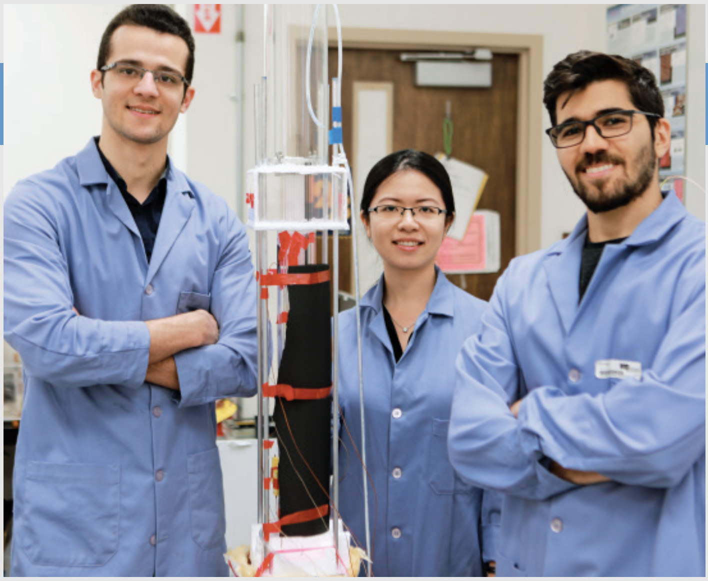
In their research, Monica and Rowan have been focusing on dispersive PDEs, which arise in the study of many wave phenomena, not just water waves, but also in describing the propagation of light and quantum mechanical wave functions. Regarding their research, Monica explains, "I'm a problem solver not a theory builder. I like to try to find the tools, or create the tools, that are needed to solve a particular problem," which is exactly what she did with the KdV equation.

The challenge was creating a new tool for the dispersive PDE community – something that would tap into the completely integrable nature of these equations. Monica explains, "There has been a gap between the integrable community and the dispersive PDE community – no one could understand why techniques in one area didn't work in the other – so the two camps had little to discuss with each other."

The synthetic approach that Monica and Rowan introduced has already borne fruit in the study of other problems. One example is the recent paper "Invariance of White Noise for KdV," written jointly with Jason Murphy (who received his PhD from UCLA in 2014). This paper concerns the construction of a "soliton soup" for KdV, that is, a description of the dynamics of a vast collection of solitons living together in thermal equilibrium.

Having first met at a conference in 2003, Monica and Rowan married in 2006. Their extensive mathematical collaboration began the same year, during a stay at the Institute for Advanced Study in Princeton. "It's quite a nice set up," says Monica, describing her working relationship with her husband. "When one of us is taking care of the kids, the other is working on our research." The couple have published over 25 papers together.

Monica has observed a new sense of enthusiasm in the KdV field now. "The paper has generated questions from other mathematicians wondering if our new method can be applied to other types of PDEs." Sharing tools or technology to solve other problems is typical within mathematics. "While I'm very focused on my own research, and I'm enjoying the success of our new result, I'm also very happy to help build new connections between mathematicians."



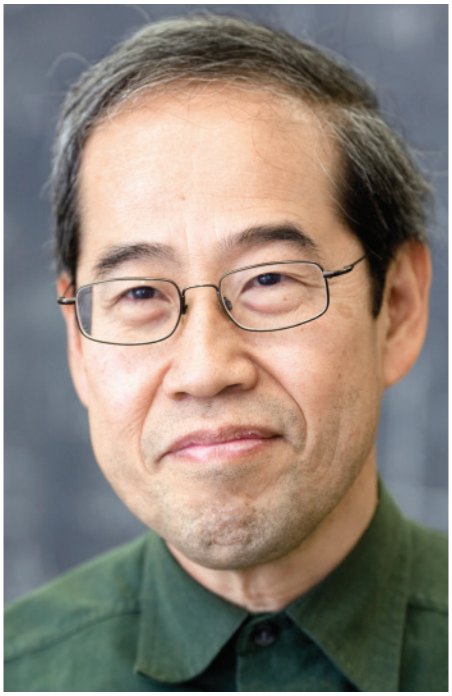
UCLA researchers (from left) Abolfazl Sadeghpour, Hangjie Ji and Navid Dehdari Ebrahimi with their experimental water capture apparatus

Capturing Water Vapor

Supported by the National Science Foundation and the Simons Foundation, researchers from the UCLA departments of mathematics and mechanical and aerospace engineering, including math faculty member Andrea Bertozzi and math postdoc Hangjie Ji, conducted a study that has resulted in a unique and effective method to capture water vapor. The system can be used to produce clean, fresh water or to recycle industrial water and has a 200 percent increase in efficiency over other existing technologies. The study addresses the growing global concern over the scarcity of fresh water.

FACULTY AT THE FOREFRONT

Haruzo Hida–It's About Creativity



The 2019 Leroy P. Steele Prize for Seminal Contribution to Research was awarded to Haruzo Hida by the American Mathematical Society for his highly original paper "Galois Representations into $GL_2(\mathbf{Z}_p[[X]])$ Attached to Ordinary Cusp Forms," published in 1986 in *Inventiones Mathematicae*.

On the threshold of his recruitment to UCLA in 1987 as a full professor, Haruzo Hida was credited for a fundamental discovery – that ordinary cusp forms occur in p-adic analytic families. His discovery is now understood throughout the mathematics field as the theory of p-adic Hecke algebras. Hida families are ubiquitous in the arithmetic theory of automorphic forms, and his research has changed the way the subject is viewed.

This contribution to the field inspired B. Mazur to conceive his deformation theory of Galois representation, it gives a foundation of the proof of Shimura-Taniyama conjecture and Fermat's last theorem by A. Wiles and R. Taylor, and it has been generalized to non-ordinary forms by R. Coleman.

Haruzo wrote the groundbreaking paper "Galois Representations into $GL_2(\mathbf{Z}_p[[X]])$ Attached to Ordinary Cusp Forms" in 1981, but acceptance of this highly original work by the academic community was slow; the paper was finally published in the journal *Inventiones Mathematicae* in 1986.

This year, Haruzo received the 2019 Leroy P. Steele Prize for Seminal Contribution to Research from the American Mathematical Society (AMS) for his discovery. While he sees the award as a great honor, it was also a big surprise. He responded, "What I did was just create something, and a lot of people got interested very early and used it to solve a lot of questions. It's just fortunate, I think."

Creating something is at the core of Haruzo's approach to mathematics. He also likes to do this alone, although he concedes that collaboration is the key to success in today's scientific world. "Theory has become so difficult that you cannot cover everything being just one person, but it used to be a one-person job, especially number theory."

The distinctive drive to go it alone precedes his professional endeavors. Born in 1952 in the beach resort town of Hamadera (presently, Sakai West-ward), Japan, Haruzo spent much of his childhood alone, reading. He was physically weak, so he couldn't play with other children. He remembers, "I lived on an estate, so I was totally isolated. I basically didn't move, because I couldn't – I had a heart problem. The only leisure I had was reading books."

At the age of 3, he was reading books in Chinese, Japanese and English. He recounts, "My father taught me English and French. My sister loved stories in Chinese classics, so she taught me that." Even now he writes poems in ancient Chinese. While he can read them, he can't pronounce the words because of the outdated dialect, but he doesn't think that's important.

Haruzo's career path has shaped both his academic style and his creative processes. At Kyoto University, he followed his own counsel. He enrolled as an undergraduate in chemistry, but his education was almost immediately disrupted by the closure of the school due to political interference. Haruzo filled the two-year hiatus with self-study in science, as well as poetry, reading and other liberal arts. When the school reopened, the students were placed in the year that they should have been in, i.e., third year for Haruzo, had they stayed enrolled, which made formal study going forward a challenging endeavor.

Haruzo determined that the only way to graduate on time was to switch to mathematics. "Math is the kind of thing I could do fast compared to chemistry where you need time to gain real experience. Math, you go through the courses and take the exams. So, it was easier for me. I did my best to make it a one-man job. I still don't really rely on somebody else's mathematics." Haruzo earned a doctor of science in 1980 without a thesis advisor and wrote his famous paper in 1981 without any collaboration.

Haruzo held faculty positions at Hokkaido

University from 1977 to 1987, though he did not have a doctoral degree for the first three years. He visited the Institute for Advanced Study (1979–1981) and the Institut des Hautes Études Scientifiques and Université de Paris Sud (1984–1986), where he was finally able to share his famous research in an academic forum. He has been a professor at UCLA for three decades.

Hauzo has conducted his research at UCLA in four areas: p-adic elliptic modular forms, p-adic Hecke algebra over number fields, a particular type of number field called CM field, and the study of cohomological modular forms. In 1998, he was promoted to Distinguished Professor of Mathematics.

“For a mathematician to survive, you need to have a good problem,” states Haruzo. “And a good problem is not just that the result is good, but you need to be able to prove it. For a very difficult problem, there is no help at all,” he laments. “Sometimes you need to invent a new area of research. I started with the simplest case and now it applies to most cases.”

Despite his independent spirit, Haruzo appreciates collegial interaction. “In some sense communication matters in math more than other areas of science because it's not studying something given by nature. Right? You start with some axioms, some rules, and you create something. And you need to communicate with fellow mathematicians. You need to convey your ideas to other people.”

Haruzo was an invited speaker at the ICM in Berkeley (1986), a Guggenheim fellow (1991–1992), a recipient of the Spring Prize from the Mathematical Society of Japan (1992), a senior scholar at the Clay Mathematics Institute (2010–2011), an inaugural fellow of the American Mathematical Society (2012), and a recipient of a Docteur Honoris Causa, Universitée de Paris XIII (2015). He is the author of seven research books and monographs on his own results.

Haruzo has tried to live his life according to an axiom expressed by a Medieval monk who suggested that the purpose of one's life could be found only in an enjoyable pastime. He says, “I finally found one accidentally in the mid-1970s, and after that, I became totally addicted to mathematics.”

In accepting the Leroy P. Steele Prize for Seminal Contribution to Research at the 125th Annual Meeting of the AMS in January 2019, Haruzo's characteristic self-effacing remarks included these: “I am hardly professional nor academic in mathematical work, and I often create mathematics without tangible reference to contemporaries. It seems unfair that such a person would be chosen for a prestigious AMS prize. Nevertheless, my work has found some deep applications. This hopefully legitimizes the award.”

Bill Duke (left) with longtime friend and ETH mathematics professor Marc Burger in Zurich

Bill Duke—Pioneer in Number Theory and Automorphic Forms

Bill Duke was honored on his 61st birthday with a conference – Arithmetic, Geometry, and Modular Forms – to celebrate his seminal contributions to this mathematics field. Hosted by the Forschungsinstitut für Mathematik (FIM), also known as the Institute of Mathematical Research, at the Swiss Federal Institute of Technology in Zurich, the conference brought together 200 mathematicians and prominent speakers from around the world.

Regarded as both a pioneer and an expert in his field, Bill's contributions in arithmetic of modular forms have provided the basis for many mathematicians in their own research. Leading the way for young academics has been a crucial part of his experience and one which he is most proud. Conference organizer and mathematician Dr. Özlem Imamoglu described his vast contributions as “a source of many applications and generalizations in the world of mathematics.”

Bill served as chair of the UCLA Department of Mathematics and has consulted on NSF panels for three decades. To date he has shepherded 11 PhD candidates through their doctoral studies and conducted over 70 invited lectures, worldwide. In 1998, he gave an invited lecture at the International Congress of Mathematicians (ICM), the largest conference in the mathematical community. He was selected as a fellow of the American Mathematical Society in 2016 “for contributions to analytic number theory and the theory of automorphic forms.”

DEDICATED TO EXCELLENCE

Navigating the Math Degree

The UCLA Undergraduate Mathematics Students' Association (UMSA) is a peer networking group where math majors and other students interested in math make friends and explore the major, the field of mathematics and career opportunities through activities designed specifically for them. UMSA is organized and run by undergraduate students with a board and officers to plan activities and lead the club.

With nearly 2,000 math majors, finding a sense of direction can be challenging for a freshman. "What classes should I take?" "How do I make friends?" "What can I do with a math degree?" "How can I get involved with research?" These are common questions that math undergrads ask on their academic journey.

Coming from a small school in Dubai, Pashmeen Kaur felt like a very small fish in a very big pond. She recalls, "My first college classroom had more students than my entire high school class!" Joining clubs, particularly UMSA, was one of the best decisions she made.

Pashmeen Kaur (center right), 2018–2019 UMSA president, with board members

Some members are introduced to UMSA during the week-long students' activities fair each fall where hundreds of student groups and campus departments assemble to welcome and introduce freshmen to the incredible bounty that UCLA offers. Other members find UMSA by referral from a friend or classmate. Non-members are welcome to attend specific events for a small fee. Full membership provides open access to all of the programs and services.

Pashmeen learned about UMSA in her first quarter by way of the students' activities fair. She signed up immediately, and after feeling more connected with the club, she decided to join the board. She subsequently served as treasurer, and this past academic year, as club president.

She chose to be involved in the mentoring program right away. "My mentor was a second-year actuarial major. She guided me through a lot of my classes, and is still one of my really good friends." The Mentor Program matches first-year math students with higher-level undergrads based on common experience, extracurricular activities, post-grad plans, interests and hobbies. Having a mentor can significantly improve a student's life and educational experience.

Says Pashmeen, "During my first year, I found it hard to find math-specific research at UCLA's Undergraduate Research Week. I knew a lot of math undergrads who wanted to get more involved in research but didn't know where to start." UMSA's Annual Research Showcase enables math students to present and share their own research to an audience of peers. It's a great way for undergrads to identify the area of math they want to pursue.

Another way to approach research is to attend the Professor Talks, which are open-ended and offered at least three times each quarter. "They give students a good start to at least have a conversation about how to get involved in research," says Pashmeen. The talks offer opportunities to meet and hear math professors in a more intimate and casual setting than the classroom. The professors are selected by the UMSA board and sent personal invitations to speak to undergrads in this forum. "It's a great way for students to learn what the faculty are interested in and what they're researching."

Pashmeen sees the Career Fair for math majors, organized every fall, as the best selling point for the club. As one of the smaller career fairs on campus, it offers students individual attention. "We specifically invite companies that are interested in hiring math majors. We've always gotten really good feedback. The reps love participating and think the students are highly professional. This year, we had the biggest turnout so far." Employers at the 2018 career fair included Boston Consulting Group, Oracle, Pacific Life, Accenture, Northwestern Mutual, Ankura Consulting, PEX, Mathnasium, Cylance and Resolution Economics.

"In a school as big as UCLA, I think you need a smaller community that you can be part of, a way to feel at home." UMSA's Coffee, Cookies + Class Planning helps undergrads socialize and plan their math curriculum at the same time. Prior to enrollment each quarter, UMSA board members make themselves available to undergrads for discussion and advice about courses. Freshmen, in particular, find this event very useful. Mathsgiving is a celebratory event for students spending the Thanksgiving holiday on campus. A purely social gathering, it is a way to share food, fun and conversation.

The Alumni Mocktail is a way to bring math alums and undergrads together. Alumni from different industries speak on a panel, sharing their math education experience and describing how their mathematical skills have influenced their career trajectories. Following the panel is a mocktail session with refreshments and networking. This opportunity is mutually beneficial: Alumni enjoy giving back to their alma mater and making a positive impact on students, and students bring a fresh perspective to alumni, sharing new research and trending topics in the field.

Pashmeen encourages math students to get involved early. "It's just about being proactive, going to the events and seeking the help you need. The friends I made along the way were the best part for me, and being a part of UMSA was definitely one of the highlights of my undergraduate experience." She will begin working on her PhD in statistics at The Ohio State University this fall.

UMSA membership is now 200 strong! Interested undergrads can sign up on the UMSA website: https://www.math.ucla.edu/~umsa/.

Myco-Fluidics Lab Wins NSF Video Competition

The UCLA Myco-Fluidics Lab was one of four winners in the National Science Foundation (NSF) 2019 We are Mathematics Video Competition. Titled "MycoFluidics: The Math of Fungal Adaptation," the video showed how the lab used mathematical modeling to discover that fungi build biological highways that are free from "traffic jams."

Sierra Foshe, an undergraduate whose work was featured in the video, said, "We think it's important to make math more accessible, so people can appreciate the wide range of applications and opportunities within the field."

Led by Marcus Roper, the lab uses math and experiments to make discoveries about the world around us. Says Marcus, "We were amazed that fungi can move so much traffic without any congestion at all. We'd love to figure out whether traditional highways could work so well!"

The National Science Foundation, We Are Mathematics Video Competition, aims to make advanced mathematics more accessible to a broad audience. Winners are determined by formal judging and receive a monetary prize, public recognition and promotion.

Sierra Foshe, an undergraduate researcher conducting an experiment in Roper's Lab

UCLA Putnam Team Moves Up to Third Place

Of the 568 institutions competing, the UCLA Putnam team (Ciprian-Mircea Bonciocat, Xiaoyu Huang and Konstantin Miagkov) ranked third in the 79th William Lowell Putnam Mathematical Competition in December 2018. This is the best result in UCLA's recent history, matching team performances in 1968 and 2012.

A total of 42 UCLA students participated in the competition. Individually, Xiaoyu Huang and Kaiqi Zhu each received a prize for ranking in the top 27 nationwide, and Osman Akar and Konstantin Miagkov received honorable mentions for ranking in the top 100.

Within the Department, Xiaoyu Huang was recognized with the Basil Gordon Prize as the top scorer among UCLA students. Longtime Putnam coach Ciprian Manolescu received the Department's Distinguished Service Award for his many years of guidance and support for Putnam competitors.

ALUMNI PAY IT FORWARD

Kirk Dunn–Vision and Initiative

For three decades, alumnus Kirk Dunn ('83) has worked as an entrepreneur, bringing innovative technology solutions to market, benefiting corporations and their customers. He currently serves on the UCLA Anderson Easton Board and the Ronald Reagan UCLA Medical Center Board. He is a longtime member of UCLA Ventures and has established an annual entrepreneurial seed fund prize as a part of Startup UCLA. For many years he has also been active in UCLA athletics, in particular, supporting men's and women's water polo.

Kirk Dunn '83

Kirk's business acumen, along with his foresight, entrepreneurial style and philanthropic sensibility has led him to pay it back and forward with a $1 million gift to UCLA for the establishment of an undergraduate major and an endowed chair in data theory. The gift derives from his belief that making a place for data science in today's academic environment and creating graduates who can apply these analytic skills in business and academics is important for our future. The gift also aligns with Kirk's conviction that UCLA is the best university to lead the field going forward.

In 1983, during his senior year at UCLA, Kirk remembers a guest speaker from Bell Labs talking about a world where everyone would be using several communication modalities to manage both work and life, and the big scientific challenge was going to be – network congestion. Kirk recounts, "I was fascinated by this statement because I knew that solving this networking problem would lie squarely in core mathematics, and the solution was going to be critical in making all these communication systems work."

Now with the ubiquitous presence of data in our lives and seemingly unlimited network access, we see even greater challenges and opportunities ahead. "There's not an area in modern living that isn't deeply analytical," Kirk points out. With the dominance of mobility, increased processing power, nearly unlimited network capacity, IoT and more, everything we touch is being stored, analyzed and repurposed in an effort to make our lives more efficient. We have just begun realizing the value of using data science for commercial and social benefit.

The applied element of data science will eventually impact every aspect of our daily lives on a global scale, including our governments, healthcare options, purchasing behavior, travel and security. By providing a rigorous introduction to the underlying principles of mathematics, statistics and computer programming, students will be prepared for graduate studies in a related field and as potential technical leaders in the field of data management and data analytics. The value of educated data leaders and researchers in this environment cannot be overstated.

Kirk believes that this is an optimal time for the still-developing field of data theory to emerge as an inclusive space. "We want to help reshape the norms and reintroduce the skillset in a new, inviting way so that we can interest a diverse set of students. That's a really important part of this effort," says Kirk, a father of three daughters himself. It's pushing against some cultural programming, for instance, the myth that girls aren't good at math, so a key part of this effort is going to be developing strategies to attract a more diverse student body to study data theory. Says Kirk, "But if anyone can do it, UCLA can because the student body, the faculty and the Los Angeles community are committed to diversity, so we already have a head start."

Students may apply to enter the major beginning in the fall quarter of 2019. Data theory is a capstone major, offering a unique four-year curriculum culminating in a senior thesis project. As an academic field of study that requires unique resources, the program will initially be limited in size, but grow as more resources are developed.

"We want to help reshape the norms and reintroduce the skillset in a new, inviting way so that we can interest a diverse set of students. That's a really important part of this effort ... but if anyone can do it, UCLA can."

— Kirk Dunn

As students move through the highly structured curriculum, they will be introduced to the mathematical and statistical foundations of data science, as well as software programming, and be shown through many examples how data solves important problems and introduces unique opportunities to understand the world around us. Students will learn to manage data correctly with skill, execute data analyses and present findings. They will master concepts of machine learning, deep learning and elements of artificial intelligence and develop and test data-driven models. Upon graduation, students will understand mathematical foundations, including pure and applied linear algebra, basic analysis, probability and optimization theory, and be able to work effectively on data science problems in a team environment using these theories.

The Dunn Family Endowed Chair in Data Theory will be held by an eminent researcher in data theory. Recruitment for this position is underway.

The Dunn Chair's responsibilities during the startup will include participating in program design and implementing the curriculum in coordination with involved faculty in the Department of Statistics. Going forward, the chair will guide and support data science activities in areas such as healthcare, economics, politics, social networking and transportation, thereby engaging with other UCLA programs on campus to make this a truly applied field of study.

UCLA math department chair Mario Bonk remarks, "One day, we would like to support an entire data theory center, a collaborative space for interdisciplinary research. The Dunn Family Chair is a great start."

A $1 million gift from UCLA math alumnus Kirk Dunn '83, matched by the Division of Physical Sciences, will launch the Dunn Family Endowed Chair in Data Theory and support the new interdisciplinary data theory undergraduate major. The chair is designated for a member of the Department of Mathematics or the Department of Statistics.

THE IMPACT OF GIVING

Veeravalli Seshadri Varadarajan 1937–2019

At its core, the academic life of Professor Emeritus Veeravalli Seshadri Varadarajan, or "Raja," as he was called by all who knew him well, was a deep personal commitment, nourished and sustained by his wife Veda. While he made continuous, significant contributions to mathematics over his 49-year career, Raja was most warmly regarded in the Department for cultivating a mathematical family of colleagues and students, extending many individual kindnesses and hosting inclusive social celebrations throughout his almost lifelong tenure.

Former student Rita Fioresi remembers, "He cared so much for us in so many ways. Veda used to prepare me fresh orange juice, afraid I was too busy to get enough vitamins, and Raja routinely brought breakfast for one student when they met early in the morning because he didn't eat any at home." His close colleague, Don Blasius, recalls Thanksgiving dinner, New Years' Day and a summer garden party at his home as Department institutions for four decades.

Raja's and Veda's commitment to UCLA was generously expressed in 2019 by a $1 million gift to establish the Ramanujan Visiting Professorship in the Department of Mathematics, honoring renowned Indian mathematician Srinivasa Ramanujan.

The gift was perhaps foretold by Raja's enthusiasm developing and leading the Department's Distinguished Lecturers Series (DLS) in its first years. His idea was to invite only the world's most famous mathematicians to stay at UCLA for a month, giving lectures and meeting formally and informally with math faculty and students. The success of the program was immediate because Raja was respected and liked by so many prominent mathematicians. The DLS became an academic tradition thereafter. In 2008, his last year leading the program, Raja was honored for his service.

Raja came to UCLA with Veda in 1965 at age 28 as an associate professor, following his PhD in 1960 and a faculty appointment at the Indian Statistical Institute (ISI) at Kolkata. There he studied under C. R. Rao with the other members of the "famous four" from ISI: K.R. Parthasarathy, R. Ranga Rao and S.R.S. Varadhan.

Raja excelled at mathematical research early in his career, playing an important role in the development of probability theory in India. Don Blasius remembers him as "a free spirit in mathematics," motivated by foundational questions and often feeling constrained by the professionalization of mathematical research as a kind of orderly problem-solving.

His research has always been motivated by a desire to understand the role of symmetry in mathematics and physics, especially the theory of representations of Lie groups, and their applications to quantum mechanics and quantum field theory. The breadth of his contributions to mathematics is significant – in its list of primary subjects, the American Mathematical Society identifies 22 fields to which Raja contributed over his long career.

Early in his UCLA tenure, Raja developed a primary interest in the theory of semisimple Lie groups and their representations, and especially the transformative theory of Harish-Chandra, who became a friend. He found Richard Arens, Donald Babbitt and Robert Blattner to be colleagues with sympathetic interests. Inspired by problems arising from Harish-Chandra's theory, Raja collaborated with Don Babbitt, from 1983 until 1991 in basic research on the theory of meromorphic differential equations with irregular singular points. They published six articles and an *Astérisque* monograph on the topic.

Over the next 25 years, Raja and collaborators T.J. Enright, J.J. Duistermaat, R. Gangolli, J.A.C. Kolk and P.C. Trombi made diverse important contributions to this developing theory. Much of his work was conducted in his Pacific Palisades home where he and Veda shared a big office, which they had added to their house. Raja worked on math and Veda painted watercolors. She always counseled him to focus on his research and not get distracted by other things. Veda has her own connection to UCLA, earning a master's degree in atmospheric sciences in 1976.

Raja's dedication to the art of teaching has always been celebrated by his students. Says Rita Fioresi, "His clarity of thought in mathematics is unparalleled in my experience. He would be so on target, always finding the clean and smart way to present a subject, from elementary to extremely advanced. Even on elementary constructions, like vector bundles or semidirect products, he wrote notes for us, his students, that we treasure and read even to today."

Eighteen students began and finished their doctorates under his tutelage. He recounted later in his career that he had to learn how to help students discover and follow their own paths, rather than impose his own. He loved to teach and explain things, and above all, to work with important ideas, writing numerous articles with students and former students. In 2007, Raja was awarded the Department's Robert Sorgenfrey Distinguished Teaching Award for his stewardship.

Raja published several textbooks for graduate students: *Lie Groups, Lie Algebras, and Representations* (1974) was the first of its kind and remains a standard reference text along with *An Introduction to Harmonic Analysis on Semisimple Lie Groups* (1989). With colleague R. Gangolli, he published a 385-page monograph in the famous *Ergebnisse* series (1988).

Throughout his career, Raja had a strong interest in the origins of the ideas of mathematics and physics, including the theory of quantum groups; problems of quantization; and novel topics, such as arithmetic, including non-archimedian physics. He became highly productive, conducting research in numerical approximations to quantum systems and their mathematical justification, problems of Fuchsian differential equations arising from quantum field theory, and the mathematical aspects of supersymmetry.

His work resulted in numerous research and expository articles on these topics. His 2004 exposition, *Supersymmetry for Mathematicians: An Introduction*, became an American Mathematical Society bestseller, and his 2006 collaborative paper, "Unitary Representations of Super Lie Groups and Applications to the Classification and Multiplet Structure of Super Particles," defined and developed the notion of a unitary representation of a Lie supergroup.

In 2006, he wrote *Euler Through Time: A New Look at Old Themes*. This highly readable book is meant for the contemporary mathematician and shows how Euler's work connects to important themes of current research. In 2011, he published *Reflections on Quanta, Symmetries and Supersymmetries*, which was called "brilliant, stimulating and informative" by a reviewer.

While he was a prodigious researcher and writer throughout his career, Raja's association with the *Pacific Journal of Mathematics* is particularly noteworthy, dating from 1985 when he assumed the role of managing editor. In 1993, he relinquished that position and remained as an editor until 1998, when he again took over the lead editorial role until 2014. He was an excellent captain of this well-known journal, maintaining its academic prominence for almost three decades. A future issue will be devoted to his work and his memory.

Though he retired in 2014, Raja's work continued until his death. He co-edited important unpublished manuscripts in which theorems announced by Harish-Chandra before his early death are given proof. This volume now forms the fifth of Harish-Chandra's collected papers; the first four volumes were edited by Raja alone. He also wrote two research articles with a former student.

Veda and V.S. Varadarajan

Raja was internationally recognized for his work throughout his career, including an honorary doctorate in physics from the University of Genoa, the Lars Onsager Medal from the Norwegian University of Science and Technology, and an invitation to speak at the International Congress of Mathematicians (ICM). For both his 60th birthday, and his retirement, conferences were held at UCLA in his honor.

Says Don Blasius, "He had heroes and mentors, just like a student, right to the end of his life, and in this way, his mathematical spirit was always young."

A memorial conference in honor of Raja will be held March 20-21, 2020, at the Institute for Pure & Applied Mathematics (IPAM). To register, or for more information, please visit https://www.math.ucla.edu/~vsvmemorial/.

The Ramanujan Visiting Professorship, established by a $1 million gift from the Varadarajans, will enable the Department of Mathematics to host eminent visiting faculty members in the specializations of representation theory and automorphic forms. The gift is part of the Centennial Campaign for UCLA, which is scheduled to conclude in December 2019 during UCLA's 100th anniversary year.

SHARING RESOURCES

Mathematics Diagnostic Testing *Four Decades On*

Established in 1978, the Mathematics Diagnostics Testing Project (MDTP) is a statewide collaboration of the University of California, the California State University and the California Academic Partnership Program. Its purpose is to promote and support student success in grades 6 through 12, and subsequently, in college mathematics courses. The UCLA Department of Mathematics is one of eight regional MDTP sites providing materials and services free of charge to California math educators.

"To say a student is not good with fractions is not useful, instructionally," says Mary Sirody, director of the Mathematics Diagnostics Testing Project (MDTP) at UCLA. "To help students make sense of this statement, teachers need to know the specific misconceptions and gaps of knowledge that contribute to a student's problems with fractions, so that instruction can be appropriately adjusted."

MDTP provides teachers with information they need to evaluate and improve students' mathematical progress, including diagnostic readiness tests, for grade 6 math through calculus. "In diagnostic testing, it's important to first get a baseline and then see, through follow-up testing, how instruction is making a difference," Mary explains. "We help teachers interpret and respond to the data so they can create strategies to improve learning, including developing new activities, based on test results."

Sample Student Letter from MDTP

To: Joe Bruin

Here are the diagnostic results from the "Algebra 1/Integrated Math 1 Readiness Test (AMR45A19)", AMR45A19, that you have recently taken. Your Score, the Critical Level, and the Total Possible score for each topic are reported below. The Critical Level for each topic is what MDTP considers to be the minimum number of correct responses for you to show adequate preparation in that topic.

	Your Score	Critical Level	Total Possible
Congratulations! Your results indicate that you have done well in each of the following topics:			
Data Analysis & Probability & Statistics	3	3	5
Functions & their Representations	4	4	5
Fractions, including Applications	5	4	6
Integers	3	3	4
Linear Equation & Inequalities	6	5	7
However, your results indicate you need review in the following topics:			
Geometry	4	5	8
Your results indicate you need substantial review in the following topics:			
Decimals, including Applications; Percents; Absolute Value	2	4	6
Exponents & Square Roots; Scientific Notation	1	3	4

Your total score is 28 out of 45, which is 62%. We hope you find this information helpful. Please contact your teacher for specific activities and assignments that will aid in any necessary review.

Following these tests, teachers receive reports that summarize and break down performance by class, student, topic (e.g., fractions) and mathematical task. As an option, students may receive reports detailing their individual test results, which diagnose their strengths and weaknesses. In this way, both teachers and students have information that can improve instruction and mathematical understanding.

In addition to diagnostic readiness tests, MDTP offers testing for 9th graders to inform high school course enrollment, written response items for critical thinking activities, and workshops that support educators who use MDTP resources. The goal is to bring long-term results to classrooms.

Mary first utilized MDTP's resources when teaching at Granada Hills High School. She quickly became an advocate, introducing other teachers to the available assistance. She has directed the MDTP program at UCLA for 12 years now and is still passionate about supporting teachers and math instruction. The program currently serves over 2,000 teachers and 500 schools across Los Angeles and Ventura counties.

With only a small staff, MDTP distributes and scores over 100,000 student tests each year, administered by both paper (old school) and online testing platforms. Mary is excited to see the program growing and impacting more schools.

Typically, teachers hear about it by word of mouth from colleagues, as Mary did when working at Granada Hills High School. To further promote program services, the staff attend regional and statewide conferences and initiatives to share the program's benefits with teachers and other educators.

MDTP aligns with the Department's outreach initiative to promote and build mathematical competence across local communities. The overarching mission of this outreach is to foster a greater appreciation for the subject matter and inspire young people to pursue careers in mathematics.

To learn more, please visit https://mdtpucla.org/.

K-12 Teacher Training *In Good Hands*

Established in 2007, The Philip C. Curtis Jr. Center for Mathematics and Teaching has a twofold commitment to the advancement of K-12 math activity in public schools: Center staff and faculty instruct and inform the undergraduate mathematics for teaching major at UCLA, which produces highly qualified middle and high school instructors, and they lead and participate in local, state and national projects that develop and improve the quality of mathematical activity in public schools across the nation.

As director of The Curtis Center, Heather Dallas provides national and statewide leadership in K-12 mathematics. She has taught math for 26 years in local public schools and the UCLA Department of Mathematics. She has served on the California Academic Content Standards Committee, the U.S. Department of Education's Race to the Top Technical Review, and the California Framework Committee. From 2015–2017, she directed a $1.3 million project to develop innovative applied mathematics problems for the end-of-year exam used by 21 states. Currently, she directs the Center's work with school districts, private companies and national and state entities. She has National Board Certification, an advanced teaching credential that goes beyond state licensure. A third-generation teacher, she firmly believes all students can appreciate the beauty and power of mathematics. A recent interview with Heather confirms this commitment:

What attracted you to mathematics?

My father taught junior high school algebra, so our family had a built-in positive disposition about mathematics. In school, I did well in math, but I was unenthused by the predominance of routine procedures and lack of reasoning and application. That changed in my senior calculus and physics classes, when my instructor, Keith Barker, a UCLA math grad, answered my whys with proofs and engaged our class in hands-on data collection and analysis. I thought, "This is philosophically interesting, and it solves real problems. Maybe I'll major in math."

Can you share some highlights from your 12 years as a high school math instructor?

My colleague and I developed a specialized two-year algebra course that gave struggling students a pathway to meet CSU admission requirements for mathematics. The hours we spent collaborating paid off with a pass rate significantly exceeding the national average. Meanwhile, I began developing lessons for the advanced calculus course I taught, employing the same sense-making, inquiry-based pedagogy we used in the algebra course. I aimed to put mathematics in real-world contexts and create a low floor/high ceiling environment to provide differentiated experiences for all students. As these pedagogies were implemented, the average number of students achieving the top score on the AP exam increased to over 80%. The results data in these two courses solidified my belief in the pedagogies that we emphasize in The Curtis Center today.

What has been most gratifying in your work with the UCLA Curtis Center?

I am most proud of our efforts to help current and future K-12 instructors develop their professional understanding of the mathematics they teach. We must ourselves understand why something is true and how it is used in order to pass those ideas on to our students. I'm particularly excited about our recent efforts to create lessons aimed at sharing elements of current research from the Department's NSF Research Experiences for Undergraduate (REU) program with high school math students. As they see what current mathematics looks like and how it helps society, we believe high school students, especially young women, will more seriously consider a career in math.

What was it like working with Phil Curtis?

Phil had a profound respect for K-12 math instructors and believed that K-12 and university faculty could learn from each other. Phil was first my professor and then my colleague as we worked to advance K-12 mathematics activity in public schools. Of utmost importance to him were the mathematical training of elementary school instructors and (what is now called) the Math for LA Program, which provides avenues for undergraduate math majors to concurrently earn a teaching credential. Today, the Center stands on the foundation Phil built and bears his characteristic philosophical trademark: It is a place where K-12 and university faculty work together. This year, the team will impact 1,500 math instructors, working with two large socioeconomically disadvantaged school districts in the state, small rural districts in eastern and northern California, and the Paskenta Band of Nomiaki Indians.

UCLA CURTIS CENTER

The Curtis Center Endowment

The Curtis Center is close to achieving a $1 million endowment. The UCLA Dean of Physical Sciences has pledged to match donations made in any amount to the endowment fund until December 31, 2019.

Your donation will help ensure the future of existing programs and provide additional ways to promote high quality mathematics in our public schools.

To donate online, use this link: https://curtiscenter.math.ucla.edu/donors/

To donate by mail, please make a check payable to "UCLA Foundation" with "The Curtis Center" on the memo line and mail to the following address: The Curtis Center, 520 Portola Plaza, Math Sciences #5602, Los Angeles, CA 90095.

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