Sum of Its Parts Results in AMS Award for UCLA Math

Lisa Mohan

The UCLA mathematics department received the 2007 AMS Award for Exemplary Achievement in a Mathematics Department. The award citation is in the May 2007 *Notices*, page 633.

Already a large department by any standards, UCLA mathematics continues to chart a path of extraordinary growth. Under the leadership of its newest and youngest chair, Christoph Thiele, the department is positioning itself as the largest pipeline into mathematical careers in the United States. This fall, the projected arrival of six new faculty to an already consummate group of fifty-two accomplished and dedicated professors will reinforce the department's position among the top twelve mathematics programs in the country (most recent National Research Council ranking) and one of the top four in applied mathematics (*U.S. News & World Report*). Its partner institute, the interdisciplinary Institute for Pure and Applied Mathematics (IPAM), recently won a five-year renewal grant from the National Science Foundation (NSF) with a substantial increase in funding as a result of its far-reaching, quality programming. The department's pioneering math education group, serving kindergarten through twelfth graders and their teachers, is finding innovative ways to increase mathematics competency in California public schools. Despite its size, indeed perhaps because of it, the UCLA mathematics department has managed to create a unique synergy among these complementary training programs. For this success, the department has garnered the second annual AMS Award for an Exemplary Program or Achievement in a Mathematics Department.

Undergraduate Education

The department's undergraduate program has experienced tremendous growth in the past decade, attracting over 850 mathematics majors in 2006. Degrees are up 56 percent from 160 in 1996 to 249 in 2006. What is the big appeal? In a word: choice. The department is a pioneer of the broad-based mathematics major. Understanding the importance that math brings to other disciplines, faculty have sought to forge partner programs with other departments, resulting in an array of undergraduate degrees impressive in scope. The department's popular joint program in mathematics and computer science in the 1980s later evolved into a host of different programs and joint majors for students. Importantly, the growth and emphasis on applied math did not happen at the expense of pure math. Indeed, in 1997 when Tony Chan (currently NSF assistant director for Mathematics and Physical Sciences) became the first applied mathematician to serve as chair, the department's two groups had forged a harmonious relationship, in part because the boundary between pure and applied mathematics is fluid and constantly shifting.

Projected 2007–2008 Academic Year

Faculty	57
Postdocs	34
Graduate students	195
Undergraduate majors	850
IPAM participants (annual estimate)	1,000

Research for Undergrads

Research Experiences for Undergraduates (REU) is an integral part of the department's undergraduate mission, involving a select subset of majors, typically twenty to thirty students per year, who are interested in research. The program has the active participation of senior faculty and postdoctoral mentors and was broadened in the last two years to include the applied mathematics laboratory. This environment provides students the opportunity to participate in real physical experiments, most recently with robotics and fluid flow. Testifying to the success of the program, Andrea Bertozzi, current director of applied mathematics, spearheaded a collaborative proposal with Harvey Mudd College for a US$1.3 million NSF research training grant to advance the careers of undergraduate students in math, engineering, and computer science. Utilizing this award, granted in July 2006, Bertozzi plans to

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Undergraduate Degrees

- Pure Mathematics
- Applied Mathematics (science/engineering)
- Math/Applied Science:
  - –Actuarial Plan
  - –Management/Accounting
  - –Medical and Life Sciences Mathematics
  - –History of Science
  - –Individual Plan (for students who have equal interest in two or three allied fields, i.e., Math/Chemistry, Math/Physics, Math/Statistics/Management)
- Mathematics of Computation
- Mathematics for Teaching (teaching careers)
- Mathematics/Economics
- Atmospheric Sciences/Mathematics

keep up to sixty undergraduates from both schools engaged in research over the next five years. Bertozzi points to the inclusive nature of research in the department, "Everyone has something to do. The trick is to identify those tasks for undergrads and show them how their work and involvement matter."

Graduate Education

The year 2000 was a turning point in the department's graduate program, with the awarding of a US$5 million NSF VIGRE (Vertical Integration of Research and Education) grant under the direction of Robert Greene. The goal of the program is to initiate changes in the way professional mathematicians are trained, specifically by promoting interaction between mathematics and other fields and by increasing the number of U.S. citizens and permanent residents in math and science. The program has expanded from 112 in its first year to a projected 195 students in fall 2007.

In 2005 the NSF recognized the success of UCLA's efforts by renewing the department's VIGRE grant. The continuing success of the program is attributable to collective faculty efforts to redevelop the program into one where students learn in a research group environment, starting early in their studies. Today the program supports the majority of the department's Ph.D. students, as well as several postdocs. In addition, funding is provided for new students to attend a summer preparatory course prior to the start of the fall semester. Over half of these students pass one of three qualifying exams before taking any courses. After the first year, Ph.D. students take special graduate seminars to streamline them into research projects. All research faculty are involved in running these seminars, with fifteen to twenty offered in every subdiscipline during any given quarter. 2006 Fields Medalist Terence Tao explains how the department's large size works to its advantage in this environment. "In our analysis group, for instance, there are seven or eight faculty and twenty graduate students who are interested in the field, so we came up with a graduate seminar where the students themselves present material. In a smaller place, we couldn't do this kind of seminar."

Graduate Student Summer Internship Program

The department sought to further broaden graduate students' research experiences in 2005, initiating a summer internship program in which students work outside the department with faculty from other disciplines or industry. The key is to draw in outside mentors, who, with no initial financial investment, gain the expertise of a young mathematician. A fruitful experience may lead to other opportunities down the road. Since the ratio of graduate students to tenure-track faculty is very high in the department compared to mathematics departments of comparable standing, the cross-collaboration is a huge benefit. Explains Bertozzi, "We have the organizational structure to leverage the time of senior faculty while providing enhanced learning experiences for students and postdocs. Everybody wins." Summer 2006 saw the participation of sixteen students working with departmental mentors in computer science, neuroscience, and electrical engineering; in the medical school's neuroimaging and neurology specialties; and at the Los Alamos National Laboratory. Industry and partner university mentors included the National Geospatial Intelligence Agency, Xerox, Digital Domain, Finantix Inc., MIT Mechanical Engineering, and the Department of Informatics at the University of Athens.

Postdoctoral Program

The department's postdoctoral program is one of the largest in the country. This year's hiring campaign will result in the addition in fall 2007 of twelve bright young researchers from all over the world. Currently, thirty-four postdocs work under various research faculty in the department, sometimes across disciplines. This integration of research interests and the opportunity to train under diverse faculty is a huge draw. Many postdocs go on to secure prestigious positions at world-renowned institutions, and some advance to faculty positions within the department, including former postdoc Terence Tao. Department chair Thiele believes that in addition to a first-rate research experience, the program provides mentoring opportunities for postdocs at the undergraduate and graduate levels that enhance their experience and are also vital to the successful synergy of the department's training programs. Postdocs are routinely encouraged to design courses for undergraduates in tandem with their research interests. Former postdoc Chad Topaz, now at the University of Southern California, assisted in the development of the

Mary Jo Robertson, photographer.

UCLA math faculty and postdocs (Chair Christoph Thiele, standing in front row, green jacket) under congratulatory banner outside UCLA's Institute for Pure and Applied Mathematics (IPAM).

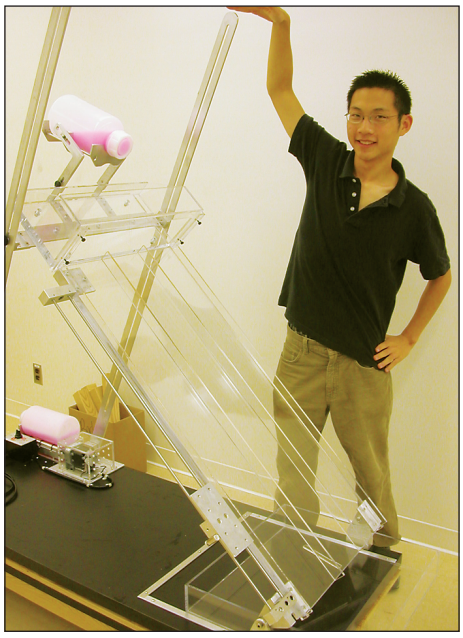
applied mathematics curriculum, designing a class on nonlinear dynamical systems. Another postdoc, Hedrick Fellow Raanan Schul, is passionate about bringing his research to undergraduates and plans to introduce a course on wavelets. Nathan Ryan, a fellow in the department's Program in Computing, has designed two undergraduate courses in mathematical cryptology and applied cryptology.

Institute for Pure and Applied Mathematics

In perhaps the most high-profile, synergistic move of the department, five math faculty—Tony Chan, Eitan Tadmor (now at the University of Maryland), Bjorn Engquist, John Garnett, and Mark Green—capitalized on UCLA's nascent culture of cross-disciplinary collaboration by creating an institute for pure and applied mathematics, or IPAM. Selected from approximately twenty competing proposals in NSF's 1998 competition, IPAM was the only new national institute created and was funded with a US$12.75 million grant. The grant was renewed in 2005 with a 36 percent increase in funding. Green, who became the institute's director in 2001, attributes its success to the size and strength of UCLA's science departments, including a first-rate medical school, together with forward-thinking mathematics faculty who are actively involved in IPAM.

As Green sees it, IPAM's mission is to bring together enterprising risk-takers in math and science, often working together for the first time, to create breakthroughs in their fields. Green remembers one of the first programs, which is exemplary of the way IPAM works: "I was trying to make contacts around campus, asking, 'Who don't I know that I should know?' One of the people who was suggested to me was Art Toga." A neuroscientist, Toga works in brain mapping and neuroimaging at UCLA's medical school. With Chan, Tadmor, and fellow faculty member Stanley Osher (who was recently elected to the National Academy of Sciences and is IPAM's director of special projects), Green met with Toga, leading to IPAM's first imaging program, Imaging in Medicine and Neurosciences. This was only the beginning of cross-fertilization of math and medicine on the UCLA campus. Chan, Osher, and Toga went on to collaborate on a major grant application, resulting in the Center for Computational Biology (CCB), one of four road map institutes funded by the National Institutes of Health. This would be only one of several large-scale initiatives IPAM helped to inspire. Department mathematicians are essential to the success of these interdisciplinary endeavors. Explains Green, "We have put computation and mathematics on everybody's radar and demonstrated by example how useful we can be."

Well over one thousand participants a year now come through IPAM's doors, interacting in programs that are designed to create visionary, interdisciplinary collaboration between mathematicians and scientists from biology, medicine, engineering, and other disciplines, as well as industry and national laboratories. The institute's mission is nationally focused and geared toward assembling a broad research community, ranging from distinguished professors to young ladder faculty, postdocs, graduate students, and undergraduates.



UCLA math undergraduate (Chi Wey) working with slurry flow experiments in Andrea Bertozzi's Applied Math Lab.

IPAM hosts two 3-month-long programs in the fall and spring, a series of short programs in the winter, a Graduate Summer School, and Research in Industrial Projects for Students (RIPS) in the summer. In a recent integrative move, the department's graduate seminar series was expanded to include participation in long programs at the institute.

Because IPAM is actively engaged with the campus at large and the wider scientific community, Green views it as an opportunity to change the culture of math—to help mathematics get where it needs to be in the twenty-first century and capitalize on the huge number of niches for mathematicians that are evolving in other fields. Critical to this goal is a strong foundation of harmonious relations between pure and applied mathematics. One of the more dramatic events that brought pure and applied together was IPAM's 2004 program, Multiscale Geometry and Analysis in High Dimensions. Together, the department's most high-profile pure math star, Terence Tao, and his Caltech colleague Emmanuel Candès, who works in applied math, used a variety of pure math ideas in harmonic analysis to create startling new ways of dealing with data. The 2007 AMS von Neumann Symposium, to be held this summer, is devoted to this topic.

RIPS

Bringing together people who would not ordinarily find themselves in the same program extends to the institute's ambitious RIPS program. Created in 2001 and inspired by Robert Borrelli's math clinic at Harvey Mudd, RIPS matches undergraduates with industry partners to work on real-world projects for nine weeks in the summer. The program has grown from twelve students working on four projects in 2001 to thirty-six students working on nine projects in 2007. Starting this summer, the program will expand to Beijing in a new partnership with Microsoft Research in Asia. Program applicants hail from a wide range of institutions, many of which are nationally prominent and some of which are abroad. The result has been an unusually diverse mix of young talent, and typically 35 to 40 percent are women.

RIPS students work in teams of four on projects initiated by industry sponsors or national laboratories. A faculty mentor, usually a postdoc, identifies the cutting-edge mathematics the students will need in order to tackle the problem. The group stays in weekly contact with their industry mentor to keep the project on track. The program provides a unique experience for students and sponsors, including working on a team, writing a group project report, and giving a team project presentation to the other project groups as well as to the industry partner. In some cases, they present their projects at conferences. Says Green, "The thing the sponsors are always amazed by is what these kids can do."

Since the program has been so successful and the institute's facilities are at capacity, IPAM has forged a partnership with Microsoft Research in Asia to bring RIPS students to Beijing this summer. Green and Director of Microsoft Research in Asia Harry Shum will assemble twenty students—ten Americans and ten Chinese—to team up on five projects. In keeping with the collaborative spirit of IPAM, each team of four will be half Chinese and half American. Green initially floated the concept of RIPS Beijing with his own kids, who validated the idea of doing really interesting research at a cool place abroad. After Beijing is up and running, the institute hopes to expand the program internationally. But as Green is quick to note, IPAM is "not out to conquer the world. We are out to benefit it."

UCLA's Math Education Programs

Like IPAM, the department's highly successful K–12 math education programs sprang from and continue to be nurtured by the efforts of innovative department educators. Professor emeritus Phil Curtis, who will turn eighty next year, is credited with inspiring all of the math education programs beginning with the Visiting High School Mathematics Teacher Program in 1979 under the leadership of then department chair Ted Gamelin. It was the first step in a decades-long relationship with California public schools and the beginning of a multipronged effort to develop teacher-leaders in math. A major step was taken in 1987 when Curtis spearheaded the establishment of the Joint Mathematics Education Program, which puts undergraduate math majors on a fast track to obtain a teaching credential through a joint program with UCLA's Graduate School of Education and Information Studies.

Gamelin currently serves in the leadership role in the math education program. In addition to his considerable expertise, the department provides office space and administrative services, such as computing and accounting. Gamelin describes the investment the department has made this way: "They trust that we're running a quality operation, and the fact that the trust is reciprocal has made

K–12 Math Education Programs

California Mathematics Project (CMP)
Executive Director: Susie Håkansson

Dedicated to the professional development needs of K–12 math teachers statewide

CMP consists of nineteen sites on University of California (UC) and California State University (CSU) campuses led by a statewide office in the UCLA Department of Mathematics. In the summer of 2007 CMP was awarded a five-year, US$5.25 million grant by the California Postsecondary Education Commission (CPEC) to focus on math teacher retention at ten of the sites.

UCLA Mathematics Content Programs for Teachers (MCPT)
Director: Shelley Kriegler

An entrepreneurial venture creating services and materials for California schools

MCPT contracts for professional development and sales of materials to client school districts, teachers, and students. Currently in development is a new textbook and program for algebra readiness in California middle schools.

Mathematics Diagnostic Testing Project (MDTP)
Site Director and Relations with Schools Coordinator:
Heather Calahan

Preparing students for high school math by identifying the key topics and skills needed for success

Founded to assess the preparedness of California freshmen for university calculus in the 1990s, MDTP develops diagnostic tests that measure student readiness for courses ranging from prealgebra to calculus. Its success led to an expansion to diagnostic tests for grades 6 through 12 and offices in ten sites.

it work." He also points out that "In math education the work often involves issues that a research mathematician would not give a second thought to but that are quite challenging and require the insight and expertise of math education professionals to address."

Gamelin brought on three educators at the start of the new century to manage three unique and independent programs that substantially support the state's K–12 math students and teachers: Susie Håkansson, Shelley Kriegler, and Heather Calahan. Their visionary direction has created a renaissance of sorts for math education, culminating this year in the UCLA Mathematics and Teaching Conference, collectively hosted by the department and the three math education groups, with the participation of over one hundred fifty local mathematics teachers and other professionals.

In addition to their professional jobs, these three math educators assist the department with curriculum design and conduct seminars and courses for preservice teachers, further contributing to the collaboration between math education and the department. Today the multifaceted program is the most extensive outreach program to the K–12 community housed in a research mathematics department.

The synergy of its comprehensive training programs is at the heart of the department's acknowledged success in educating current and future mathematicians. The faculty make the most of the department's large size to maximize students' learning experiences. The southern California weather might have something to do with the natural harmony in the department, and certainly the large concentration of scientific capital in the southern California area is an advantage. UCLA's culture of interdisciplinary collaboration that made IPAM possible is also a big factor. Bottom line, the department is a collaborative bunch that sees itself at the forefront of raising the profile of math in society at large and preparing the way for the unprecedented opportunities for mathematicians in the twenty-first century.