Department of Mathematics

The Department of Mathematics at MIT seeks to improve upon its top ranking in both research and teaching by aggressively hiring the very best faculty, with special attention to the recruitment of top women and underrepresented minority candidates and by continuing to serve the broad and varied educational needs of its graduate students, the mathematics majors, and all undergraduates of the Institute.

Students

During academic year 2004, there were 304 undergraduates majoring in mathematics, 263 in Course 18 Mathematics and 41 in Course 18-C Mathematics/Computer Science. Bachelor of science degrees, including double majors, were awarded to 106 students, 94 in Course 18 and 12 in Course 18-C. There was a total of 120 graduate students in mathematics, all in the PhD program. This year 21 students received the doctoral degree and two students received the master's degree.

Faculty Changes

Professor emeritus William Ted Martin, who joined the Mathematics faculty in 1938, serving as department head from 1947 to 1968 and as chair of the MIT Faculty from 1969 to 1971, died in May 2004 at the age of 92. During his tenure as department head, Professor Martin proposed and instituted the CLE Moore instructorship program and guided the department through its most major expansion to the world center it is today. Specialized in complex variables and harmonic analysis, Professor Martin collaborated on fundamental results in his fields and was a highly respected author and editor of mathematics textbooks. He maintained a lifelong dedication to teaching and curriculum development, teaching calculus at MIT and continuing his service to the African Mathematics Program after retiring from MIT in 1976.

Professor emeritus George W. Whitehead Jr., who served on the mathematics faculty from 1949 to 1985, died in April 2004 at the age of 85. Professor Whitehead was one of the world's leading algebraic topologists and one of the central developers of homotopy theory. He was among the first to master the technology of spectral sequences and used it to initiate a systematic calculation of the homotopy groups of spheres. His 1962 paper, "Generalized Homology Theories," established the language and basic structure underlying a great part of contemporary algebraic topology. Professor Whitehead was a very successful graduate advisor and lecturer, mentoring some of the brightest of the next generation of topologists. Among his distinctions, Professor Whitehead was selected as a fellow of the American Academy of Arts and Sciences in 1954, a National Science Foundation senior fellow from 1965 to 1966, and was elected a member of the National Academy of Sciences in 1972.

Professor Sy David Friedman resigned from MIT for a faculty appointment at the Institute of Logic at the University of Vienna.

Associate professor John Bush received tenure; he specializes in experimental fluid dynamics.

Associate professor Daniel Spielman received tenure; he specializes in theoretical computer science studies.

Assistant professor Denis Auroux (symplectic geometry) was promoted to associate professor.

Dr. Steven G. Johnson will join the department as assistant professor of applied mathematics. A graduate of MIT and postdoctorate in the Harvard Physics Department, Dr. Johnson is a large-scale computationalist and analytic theorist.

Assistant professor David Ingerman resigned from MIT.

Administration

Professor Michael Sipser will succeed Professor David Vogan as department head.

These faculty will continue to chair the following committees: Professor Pavel Etingof as chair of the Graduate Student Committee and Professor Ruben Rosales as chair of the Applied Mathematics Committee. Professor Michel Goemans will follow Michael Sipser as chair of the Committee of Advisors; Professor Haynes Miller will succeed Michael Artin as chair of the Undergraduate Committee; and Professor Tomasz Mrowka will follow Professor David Jerison as chair of the Pure Mathematics Committee.

Research

Here are a few snippets from the great range of research under way in the department.

Professor Sigurdur Helgason has made progress in the study of the X-ray transform and the Fourier transform on symmetric spaces.

In a series of joint papers, Victor Kac and M. Wakimoto have developed a unified representation theory of superconformal algebras (important for conformal field theory) through the use of quantum Hamiltonian reduction. With A. De Sole, Professor Kac also developed a new notion of a nonlinear Lie algebra and nonlinear conformal algebra; and with D. Fattori and A. Retakh, he also developed a structural theory of Lie conformal superalgebras.

Professor Steven Kleiman wrote a monograph giving the first detailed development of Grothendieck's theory of the Picard scheme. In addition, in collaboration with R. Piene of the University of Oslo, he represented the functor of equisingular sequences of infinitely near points of a smooth family of surfaces and proved that, when the representing scheme is divided by the automorphism group, the quotient is the scheme of equisingular complete ideals.

Associate professor Martin Bazant has developed a new statistical theory of cooperative diffusion in dense granular flow called the *spot model*. The theory is a first step toward a microscopic understanding of how strong packing constraints affect diffusion in dense disordered systems, which may include various glasses as well as granular materials. The goal is to replace the Boltzmann classical kinetic theory, based on single-particle random walks due to molecular collisions, with a new mathematical description of how a particle moves collectively with its "cage" of neighbors.

Associate professor Santosh Vempala found a new algorithm for estimating the volume of a convex body. The key ingredient is a technique to rapidly "morph" one convex body into another. Somewhat surprisingly, the method requires only about n points for a body in n-dimensional space. On another note, his book, *The Random Projection Method*, was scheduled for publication by the American Mathematical Society in August 2004.

Assistant professor Denis Auroux, in collaboration with L. Katzarkov and D. Orlov, has studied the homological mirror symmetry conjecture for certain types of Fano varieties—in particular, weighted projective planes and their noncommutative deformations. With S. Donaldson and L. Katzarkov, he is also studying the existence, constructions, and topological properties of Lefschetz pencils on smooth 4-manifolds equipped with degenerate symplectic structures.

Nine MIT undergraduates participated with five mathematics graduate student mentors in the department's 7th Summer Program in Undergraduate Research (SPUR), which offers a six-week program of full-time research experience, culminating in written papers and lectures to faculty. The award, selected by a jury of senior faculty, consists of a joint prize to both the undergraduate and mentor for the best paper. Two such joint SPUR prizes were given in AY2004.

Summer 2003 was the 11th year of the Mathematics Department's participation in the Research Science Institute (RSI) program for gifted high school students in various areas of science and engineering. The department had seven mathematics graduate students mentoring 13 high school students from the United States and abroad for a five-week period. One of the mentored students went on to become the 4th-place finalist in the Intel Science Talent Search for 2004 and the 3rd-place winner of the Siemens Westinghouse Competition in Math, Science and Technology for 2004. For the latter distinction, she received a $25,000 scholarship for university studies. The project she submitted to these competitions was based on her work in RSI.

Honors, Prizes, and Awards

Institute Professor Isadore Singer shared with Sir Michael Atiyah the 2004 Abel Prize, given by King Harald of Norway in a ceremony at the University Aula in Oslo, Norway, on May 25, 2004. This is the highest distinction for landmark work in mathematics, likened to the Nobel Prize. This is the second year of the award. The citation of the Abel

Committee reads in part, "for the discovery and proof of the index theorem, bringing together topology, geometry and analysis, and their outstanding role in building new bridges between mathematics and theoretical physics."

Professor Bonnie Berger was elected as a fellow of the Association for Computer Machinery for contributions to computational molecular biology.

Professor Michel Goemans received the Dean's Education and Student Advising Award of the MIT School of Science.

Professor David Jerison was selected as a 2004 MacVicar Faculty Fellow for his instruction and innovative design work of the core undergraduate mathematics subjects.

Professor Richard Stanley was chosen to be a 2004 senior scholar by the Clay Mathematics Institute.

Professor Daniel Stroock was elected as a foreign member of the Polish Academy of Arts and Sciences.

Professor Gang Tian was elected fellow of the American Academy of Arts and Sciences.

Associate professor John Bush was selected by a departmental committee to be the first recipient of the Edmund F. Kelly Research Award for his innovative work in fluid mechanics. The award is given to a junior faculty member "in recognition of work that applies mathematical methods to a new area or that offers a fundamentally new perspective on a classical problem."

Associate professor András Vasy and CLE Moore instructor Akshay Venkatesh received Clay Research Fellowships by the Clay Mathematics Institute.

Assistant professor Jeff Viaclovsky received an Alfred P. Sloan Research Fellowship.

Concerning the graduate students, the Housman Graduate Student Teaching Award was presented to Frederic Latour and Benjamin Stephens for their exceptional skill and dedication to teaching. Alexei Oblomkov and Lauren Williams were awarded the Charles W. and Jennifer C. Johnson Prize for an outstanding research paper accepted in a major journal by a graduate student in mathematics. The Clay Mathematics Institute selected Brian Osserman, Max Lieblich, and Etienne Rassart for its Liftoff postdoctoral research program for summer 2004.

Senior Maksym Fedorchuk was awarded the Jon A. Bucsela Prize in Mathematics in recognition of distinguished scholastic achievement. Among those seniors awarded degrees in mathematics, 24 were elected to Phi Beta Kappa.

The MIT Mathematics team, comprised of juniors Reid Barton and Yevgeny Zaytman, together with freshman Daniel Kane, finished first in the 2003 William Lowell Putnam Intercollegiate Mathematical Competition, whose participants included 3,615

undergraduates from 479 colleges and universities across the United States and Canada. This was MIT's fifth 1st-place ranking in the 64-year history of the competition. Reid Barton and Daniel Kane were among the five highest-ranking individuals and were therefore designated Putnam fellows. MIT had five other individuals who scored in the top 26 and received cash prizes. Another 12 MIT students were given honorable mention for finishing in the top 70. MIT had a total of 120 participants. (The figures for honorable mention and total participants appear to be all-time records for a single university in the competition.)

Education

Quality of Teaching

The program to mentor new recitation instructors in the department's large service courses has produced an improvement in average student ratings of those instructors; the average is now greater than 5 on a scale of 1 to 7. Most of our recitation instructors are graduate student TAs. In addition to the department's mentoring program, the Charles and Holly Housman Award for Excellence in Graduate Student Teaching has fostered a lively interest in teaching among the graduate students.

Computer-Aided Teaching of Mathematics

As mentioned in the 2003 report, this program developed by professors David Jerison, Haynes Miller, and Gilbert Strang, with the support of the D'Arbeloff grant, is progressing nicely to broaden the active learning experiences of the classroom through visualization tools that can be student manipulated. Recent additional projects to these efforts are as follows:

- Professor Daniel Kleitman has created an online calculus textbook, complete with a collection of Java applets. Variants have been used by David Jerison in the main 18.02 Calculus subject.
- Gil Strang has produced an indexed video version of 18.06 Linear Algebra, which has been installed on OpenCourseWare.
- Haynes Miller has introduced a variety of active learning methods into the classroom—both in lectures, where several classes have adopted Harvard Professor Eric Mazur's methods, and in recitations, where group work has been encouraged.

Progress on New Laboratory-Style Subject

The 2003 report to the president mentioned the development of a new laboratory-style subject, based on a Cambridge University course, Computer-Aided Teaching of All Mathematics. In broad outline, teams of two or three students choose a project from a list that is provided, work on it, write a lab report, and sometimes make an oral presentation. The lab course was offered for the first time in spring 2004 with an enrollment of 28, with each of the teams required to complete three projects in the term. The department is very satisfied with the results. Discussions are under way with the

Taskforce on Educational Commons to consider and modify the course to fit the Institute's criteria as an official laboratory subject.

David A. Vogan Jr.
Department Head
Professor of Mathematics

More information about the Mathematics Department can be found on the web at http://www-math.mit.edu/.