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 emphasis on recruiting 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 2006, there were 300 undergraduates majoring in mathematics, 263 in Course 18 Mathematics and 37 in Course 18C Mathematics with Computer Science. Bachelor of Science degrees, including double majors, were awarded to 69 students, 58 in Course 18 and 11 in Course 18-C. There were a total of 109 graduate students in mathematics, all in the PhD program. This year, 23 students received a doctoral degree, and two students received a master's degree.

Faculty Changes

Professor Gerald Sacks retired from MIT after 39 years on the faculty. A major figure in mathematical logic, Professor Sacks made significant contributions to recursion theory. In 1994, the Sacks Prize was established in recognition of the most outstanding thesis in mathematical logic. Professor Sacks continues his faculty appointment at Harvard University, where he has held a joint appointment since 1972.

Associate professor Gigliola Staffilani was promoted to professor of mathematics. She is an analyst concentrating on dispersive nonlinear wave PDEs.

Associate professor Denis Auroux received tenure; he works in symplectic geometry.

Assistant professor Dmitry Panchenko, an applied probability theorist and mathematical statistician, was promoted to associate professor of mathematics.

Assistant professor Alexander Postnikov, who works in algebraic combinatorics, was promoted to associate professor of applied mathematics.

Assistant professor Jeffrey Viaclovsky, who works in geometric analysis, was promoted to associate professor of mathematics.

Dr. Benjamin Brubaker will join the department as assistant professor of mathematics. He is a number theorist who graduated from Brown University in 2003 and has since been appointed Szegö assistant professor at Stanford University.

Dr. Eric Lauga will join the department as assistant professor of applied mathematics. A graduate of Harvard's Division of Engineering and Applied Science's program in 2005, he has since been appointed postdoctoral research associate in the Department of Mechanical Engineering at MIT. Dr. Lauga works in fluid dynamics.

Professor Aise Johan de Jong resigned from MIT for a faculty appointment at Columbia University.

Professor Gang Tian resigned from MIT for a faculty appointment at Princeton University.

Administration

Professor Michael Sipser will continue as department head.

Professor Alar Toomre will follow Professor Rodolfo Ruben Rosales as chair of the Applied Mathematics Committee.

The other faculty committee chairs will remain as follows:

> Professor Pavel Etingof, chair of the Graduate Student Committee
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> Professor Michel Goemans, chair of the Committee of Advisors
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> Professor Haynes Miller, chair of the Undergraduate Committee
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> Professor Tomasz Mrowka, chair of the Pure Mathematics Committee

Research

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

Professor Richard Dudley is continuing his research on scatter functionals for multivariate distributions in statistics, as well as on nonlinear analysis with special emphasis on p-variation.

Professor Sigurdur Helgason is working on problems in the field of radon transforms. Working together, he and Professor François Rouvière (Université de Nice) have proved several inversion formulas for the X-ray transform for Cartan symmetric spaces. Professor Helgason has also proved a geometric refinement of the support theorem for the horocycle transform on a symmetric space in the case of rank 1.

Professor Steven Kleiman has begun a study of the canonical model of an arbitrary singular algebraic curve in collaboration with Professor Renato Martins, who is visiting from Universidade Federal de Minas Gerais, Brazil. They have already found modern proofs of Rosenlicht's 1952 pioneering results and have generalized Noether's theorem that the canonical ring is generated by elements of degree 1, to a curve with Gorenstein singularities, and with at most one, almost-Gorenstein singularity.

Professor Gilbert Strang completed two papers on maximizing flow through a domain, involving a new proof of the isoperimetric theorem about maximum area with given perimeter.

Associate professor Santosh Vempala, in collaboration with graduate student Luis Rademacher, found a novel connection between the complexity of randomized algorithms and basic questions in convex theory, leading to improved lower bounds for several fundamental problems.

Assistant professor Mark Behrens is working with CLE Moore instructor Tyler Lawson on a project to detect families of elements in the stable homotopy groups of spheres using automorphic forms. These constructions would provide a link between algebraic topology and number theory.

Assistant professor Katrin Wehrheim, in joint research with Professor Dietmar Salamon (ETH Zürich), has completed the definition of a new Floer homology for three-manifolds with boundary. They hope to use the definition as intermediary in the identification of three-manifold invariants arising from symplectic topology or gauge theory. In joint work with Professor Chris Woodward (Rutgers University, New Brunswick, NJ), they have achieved a novel type of isomorphism between symplectic Floer homologies of different manifolds related by a Lagrangian correspondence. This paves the way toward a Floer theoretic symplectic category with natural functors associated to Lagrangian correspondences. It also yields new three-manifold and knot invariants.

In summer 2005, eight MIT undergraduates and four mathematics graduate student mentors participated in the department's ninth 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. A prize award, selected by a jury of senior faculty, consists of a joint prize to the undergraduate and mentor producing the best paper. Two such joint SPUR prizes were given; the undergraduate winners were sophomore Nikhil Savale and freshman Nathaniel Ince.

Summer 2005 was the 13th year of the Mathematics Department's participation in the Research Science Institute summer program for gifted high school students in various areas of science and engineering. The department had 12 mathematics graduate students mentoring 21 high school rising seniors for five weeks.

Honors, Prizes, and Awards

Professor Tobias Colding was elected as a foreign member of the Royal Danish Academy of Sciences and Letters and was named Honorary Professor by the University of Copenhagen.

Professor Daniel Freedman was corecipient (with Sergio Ferrara and Peter Van Nieuwenhuizen) of the 2006 Dannie Heineman Prize: "For constructing supergravity, the first supersymmetric extension of Einstein's theory of general relativity, and for their central role in its subsequent development." Professor Freedman was also recognized as a distinguished alumni fellow by the University of Wisconsin-Madison Department of Physics.

Professor Michel Goemans was selected by department faculty to be the next Robert E. Collins Distinguished Scholar, in support of his research activities in combinatorial optimization.

Professor Richard Melrose was selected as the next chair holder of the Simons Professorship of Mathematics, in recognition of his leadership role in research and education.

Professor Haynes Miller received the Graduate Student Council Teaching Award of the School of Science.

Associate professor Denis Auroux received the School of Science Prize for Excellence in Undergraduate Teaching.

Assistant professor Kiran Kedlaya received an Alfred P. Sloan Research Fellowship.

Assistant professor Alexander Postnikov was selected by the department to receive the Edmund F. Kelly Research Award for his work in algebraic combinatorics.

Lecturer Dionisios Margetis received the School of Science Prize for Excellence in Graduate Teaching.

Graduate students Alice Chan, Christina Goddard, and Pak Wing Fok received the Housman Graduate Student Teaching Award for their exceptional skill and dedication to undergraduate teaching.

Vigleik Angeltveit and Fu Liu 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. They were also selected by the Clay Mathematics Institute for the Liftoff postdoctoral research program for summer 2006.

Senior Jacob Fox was awarded the Jon A. Bucsela Prize in Mathematics in recognition of distinguished scholastic achievement. Fox also received the 2006 Frank and Brennie Morgan Prize for outstanding research in mathematics by an undergraduate student. The Morgan Prize is sponsored by the American Mathematical Society (AMS), the Mathematical Association of America (MAA), and the Society for Industrial and Applied Mathematics (SIAM).

Junior Daniel Kane received a Barry M. Goldwater Scholarship, awarded by the Goldwater Scholarship and Excellence in Education Foundation.

The MIT Mathematics team, composed of senior Vladimir Barzov and juniors Timothy Abbott and Daniel Kane, finished fourth in the 2005 William Lowell Putnam intercollegiate mathematics competition, whose participants included more than 3,500 undergraduates from 500 institutions across the United States and Canada. For the second consecutive year, three MIT undergraduates were among the six highest-ranking individuals and were therefore designated Putnam Fellows. The MIT Putnam Fellows were junior Daniel Kane and sophomores Oleg Golberg and Matthew Ince. MIT had six other students ranked in the top 24, and 14 more received honorable mentions for finishing in the top 75. This total of 23 undergraduates receiving honorable mentions or higher appears to be an all-time record for a single institution in the Putnam Competition.

The MIT team of Daniel Gulotta, Daniel Kane, and Andrew Spann was selected for the highest category of Outstanding Winners in the 2006 Mathematical Contest in Modeling Competition of The Consortium for Mathematics and its Applications. In addition, the team's paper received one of three Institute for Operations Research and Management Science (INFORMS) Prizes for a top paper in discrete mathematics.

Among those seniors awarded degrees in mathematics, 10 were elected to Phi Beta Kappa.

Resource Development

In FY2006, the Department of Mathematics launched a $15 million campaign for faculty recruitment and retention and for graduate student support, running through spring 2008. In consultation with John Reed, chair of the department's visiting committee, we designed the campaign to meet the department's needs in endowed chairs and graduate fellowships. The campaign received a major leadership gift of $6 million, offered as matching funds for the duration of the campaign.

Education

Service Teaching

The faculty actively engaged in service teaching in the Department of Mathematics is undergoing rapid turnover. For example, Associate professors Denis Auroux and Gigliola Staffilani have been lecturing in the main calculus subjects over the past couple of years. Associate professor John Bush will teach 18.02A Calculus this year, and associate professor Lars Hesselholt will lead 18.022 Calculus, taking over from Professor Hartley Rogers, who led the subject for many years.

The department continues to experiment with novel teaching approaches. Under a grant from the Cambridge-MIT Institute, Professors Haynes Miller and Gigliola Staffilani, in collaboration with Professor Warren Seering of the Department of Mechanical Engineering, introduced "supervisions," in the style of the University of Cambridge, into the standard multivariable calculus subject 18.02 in fall 2005. The success of this intervention was carefully assessed, and efforts are under way to continue it in this or other subjects in the future.

The Major

We have worked hard over the past few years to create subjects with which our majors can fulfill their departmental communications requirement. This task has been harder in this department than in most others because (1) we have an exceptionally flexible pathway through the major, making it hard to integrate training and practice of communications skills into a few subjects that all our majors take, and (2) the subjects taken by the largest groups of our majors are also taken by a wide range of nonmajors (for whom an added communications-intensive component serves as *disincentive*). The principal mode of fulfilling the communications requirement in mathematics (CI-M) is now through the undergraduate seminar system. These subjects are capped at 12 students. The students lecture, write exercises, and write a revised paper. We now offer

seminars in analysis, discrete mathematics, theoretical computer science, information theory, logic, algebra, topology, and geometry. The new mathematics project laboratory, now accredited as satisfying the Institute laboratory requirement as well as the CI-M requirement, will be given both terms this year. We also offer a six-unit subject to add CI content to the basic 18.310–18.311 Principles of Applied Mathematics, a writing subject led in some form for many years by Professor Steven Kleiman. In spring 2006, we also offered a 15-unit enhancement of the basic 18.100 Analysis I, incorporating recitations to provide time for instruction and practice in communication of mathematics.

The group of mathematics majors has never been better. By way of illustration, the MIT team, coached by Professors Hartley Rogers and Richard Stanley, took first place in the William Lowell Putnam Competition (the major collegiate mathematics competition) in 2003 and 2004. As previously mentioned, in 2005 they placed fourth, but three of the five Putnam Fellows were from MIT, and, incredibly, 23 of the top 75 scores in the whole competition went to MIT students. The mathematics majors have also won the prestigious AMS-MAA-SIAM Frank and Brennie Morgan Prize for undergraduate research in both of the last two years: Reid Barton in 2005 and Jacob Fox in 2006.

One reason for the increase in the number of highly talented undergraduates is the very successful participation by the department, under the leadership of Hartley Rogers, in the high school Research Science Institute program. Professor Rogers also directs a unique SPUR, now funded mainly by the department (following several years of seed money from the dean of science). Direction of these programs has now passed into the hands of Professor David Jerison.

Teacher Training

The Department of Mathematics continues to do a careful job in training its new teachers, both graduate teaching assistants and incoming instructors.

Graduate students and undergraduate recitation instructors must first observe an ongoing recitation and give a portion of one class. Their mentors discuss their performance and student feedback with them. They must then pass the six-hour microteaching workshop, which the department offers under the directorship of Professor Michel Goemans, just before the start of each semester (before new teachers are allowed to teach recitations in mathematics service subjects).

Incoming instructors are included in this workshop. All new recitation teachers are videotaped, and a faculty member (Professor Arthur Mattuck in recent years) observes the tapes and writes detailed comments, which are delivered to the teacher.

Michael Sipser
Department Head
Professor of Applied Mathematics

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