

## 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 2005, there were 279 undergraduates majoring in mathematics—243 in Course 18 Mathematics and 36 in Course 18-C Mathematics/Computer Science. Bachelor of science degrees, including double majors, were awarded to 109 students—95 in Course 18 and 14 in Course 18-C. There were 104 graduate students in mathematics, all in the PhD program. This year 30 students received the doctoral degree and 2 students received the master's degree.

### Faculty Changes

Professor Roman Bezrukavnikov will join the department's faculty as professor of mathematics. A graduate of Tel Aviv University and on the faculty of Northwestern University, Bezrukavnikov is a specialist in geometric representation theory.

Professor Tobias Colding joined the department in January 2005 as professor of mathematics. A graduate of the University of Pennsylvania, Professor Colding was on the faculty of the Courant Institute of Mathematical Sciences, New York University. His field is differential geometry with concentration on Riemannian geometry.

Associate professor Pavel Etingof was promoted to full professor and works in the fields of representation theory and quantum groups.

Professor Michael Hopkins resigned from MIT for a faculty appointment at Harvard University.

Associate professor András Vasy received tenure; his research is in microlinear analysis.

Associate professor Hubert Bray resigned from MIT for a faculty position at Duke University.

Associate professor Daniel Spielman resigned from MIT for a professorship in applied mathematics and computer science at Yale University.

Assistant professor Igor Pak, a discrete mathematician, was promoted to associate professor of applied mathematics.

Dr. Mark Behrens was promoted to assistant professor from a CLE Moore instructorship; his field is algebraic topology.

Dr. Philip Bradley will join the department as assistant professor of applied mathematics. A graduate of MIT and postdoctoral researcher at the University of Washington, Dr. Bradley works in computational molecular biology.

Dr. Katrin Wehrheim (symplectic geometry) will join the department as assistant professor. She graduated from Eidgenössische Technische Hochschule Zürich, in Switzerland, and is a member of the Institute for Advanced Studies.

## Administration

Professor Michael Sipser succeeded Professor David Vogan as department head.

The faculty committee chairs were: Professor Pavel Etingof, chair of the Graduate Student Committee; Professor Michel Goemans, chair of the Committee of Advisors; Professor Haynes Miller, chair of the Undergraduate Committee; Professor Tomasz Mrowka, chair of the Pure Mathematics Committee; Professor Ruben Rosales, chair of the Applied Mathematics Committee.

## Research

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

Professor Victor Kac is developing a method for quantum Hamiltonian reduction in the framework of vertex algebras. This led to a unified representation theory of superconformal algebras, which play an important role in theoretical physics. Another direction of his research concerns the theory of infinite-dimensional primitive supergroups of transformations.

Professor Steven Kleiman has continued his long-standing investigation into the structure of the compactified Jacobian of a singular curve. In collaboration with Professor Eduardo Esteves of the Instituto de Matemática Pura e Aplicada in Rio de Janeiro, Brazil, Professor Kleiman wrote a proof concerning the application of the Abel map to a singular curve.

Professor David Vogan and CLE Moore instructor Dan Ciubotaru are working with a group of about a dozen mathematicians to design a software package that can answer questions about the structure and unitary representations of reductive Lie groups. Many problems in this field can be solved in principle using algorithms that have been known for decades, but carrying out the computations has often proved intractable. Improved understanding of the mathematics and faster computers have brought some interesting theorems within computational reach.

Associate professor Denis Auroux is studying the topology of symplectic Lefschetz fibrations and the classification of these fibrations as fiber sum operations. He is also studying the homological mirror symmetry conjecture for blowups of the complex projective plane and their noncommutative deformations.

Associate professor Martin Bazant predicted a new class of fluid flows in electrolytes driven by electric fields applied near metal or dielectric surfaces that is called “induced-

charge electro-osmosis” (ICEO). Bazant’s group has worked extensively on the mathematical theory and simulation of ICEO, and in 2004 one of his PhD students (in mechanical engineering) succeeded in experimentally observing ICEO. This paves the way for new types of portable or implantable microfluidic pumps and mixers (e.g., for biomedical applications). Bazant’s group has also developed new conformal mapping methods to describe fractal growth patterns in fluid flows, as well as new exact solutions to the Navier-Stokes equations. The department’s dry fluids lab is also working toward a theory of dense granular flow by combining large-scale simulation and experiments.

Associate professor Santosh Vempala found (through an elementary proof) that the classical perceptron algorithm becomes a polynomial-time method for solving linear programs when equipped with a simple rescaling step.

Ten MIT undergraduates participated with six mathematics graduate-student mentors in the department’s 8th 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 in AY2005.

Summer 2004 was the 12th year of the Mathematics Department’s participation in the Research Science Institute program for gifted high school students in various areas of science and engineering. The department had 10 mathematics graduate students mentoring 15 high school students for a five-week period.

### **Honors, Prizes, and Awards**

Institute Professor Isadore Singer received the 2005–2006 James R. Killian Jr. Faculty Achievement Award for his fundamental work “covering a broad spectrum of geometry, analysis and algebra.”

Professor Michael Artin received the Harvard Graduate School of Arts and Sciences Centennial Medal for being “an architect of the modern approach to algebraic geometry.” This is in honor of Harvard alumni “who have made contributions to society that emerged from their graduate study at Harvard.”

Professors Alan Edelman and Gilbert Strang received the Ford Prize of the Mathematical Association of America (MAA) for their paper, “Pascal Matrices,” to be presented at the MAA Summer meeting, August 2005.

Professor Thomas Leighton was inducted into the National Academy of Engineering. He was also made a Trustee of the American Academy of Arts and Sciences.

Professor George Lusztig was named honorary member of the Mathematics Institute of the Romanian Academy.

Professor Haynes Miller was selected as a 2005 Margaret MacVicar Faculty Fellow for his outstanding teaching abilities and leadership in the design work of the core undergraduate mathematics subjects.

Professor Gilbert Strang was honored with the John von Neumann Medal of the U.S. Association for Computational Mechanics (USACM), to be presented at the 8th National Congress on Computational Mechanics in July 2005. The John von Neumann Medal is the highest award of the USACM, honoring “individuals who have made outstanding, sustained contributions in the field.”

Associate professor Denis Auroux and assistant professor Jason Starr each received an Alfred P. Sloan Research Fellowship.

Associate professor Santosh Vempala was selected for a John Simon Guggenheim Foundation Fellowship for his work on algorithmic convex geometry.

Concerning the graduate students, Andrew Brooke-Taylor and Michael Ching received the School of Science Dean’s Educational and Student Advising Award. The Housman Graduate Student Teaching Awards were presented to Andreas Malmendier, Bianca Santoro, Damiano Testa, and Dragos Oprea for their exceptional skill and dedication to teaching. Thomas Lam was 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 Vasilij Dolgushev, Chris Douglas, and Thomas Lam for its Liftoff postdoctoral research program for summer 2005.

Seniors Reid Barton and Karola Meszaros were awarded the Jon A. Bucsele Prize in Mathematics in recognition of distinguished scholastic achievement.

Reid Barton also received the 2004 Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student, and Karola Meszaros was presented with the Association of MIT Alumnae Senior Academic Award for outstanding academic excellence and professional achievement by a woman at the Institute. Junior Mihai Patrascu, a mathematics major with computer science, was selected for the Outstanding Undergraduate Award of the Computing Research Association.

The MIT Mathematics team, comprised of seniors Reid Barton and Emanuel Stoica together with sophomore Daniel Kane, finished first in the 2004 William Lowell Putnam Intercollegiate Mathematical Competition, whose participants included more than 3,800 undergraduates from more than 490 universities across the United States and Canada. This was MIT’s second consecutive first-place finish and sixth first-place ranking in the 65-year history of the competition. Reid Barton and Daniel Kane were among the five highest-ranking individuals and were therefore designated MIT Putnam fellows, as was MIT junior Vladimir Barzov. MIT had four other students who scored in the top 26, and another 13 were given honorable mention for finishing in the top 70.

The MIT team of Andrew Spann, Dan Gulotta, and Daniel Kane was a winning team of the Mathematics Contest Modeling competition of the Consortium for Mathematics and Its Applications.

Among those seniors awarded degrees in mathematics, 19 were elected to Phi Beta Kappa.

## Education

### Service Teaching

The faculty actively engaged in service teaching in the Mathematics Department is undergoing a rapid turnover, with a number of younger faculty starting to shoulder some of the load. For example, associate professors Denis Auroux and Gigliola Staffilani have been lecturing on the main calculus subjects over the past couple of years. This turnover is essential since we anticipate the retirements of several senior faculty who have borne more than their share of this load historically.

For a number of years, four Mathematics Department faculty members (professors David Jerison, Daniel Kleitman, Haynes Miller, and Gilbert Strang) have been working under a grant from the d'Arbeloff Fund to institute a number of improvements in the service teaching. An imaginative online calculus textbook has been produced, and a suite of interactive computer applications has been written to help students visualize and explore concepts from calculus—especially differential equations. These applications have been used for several years now as lecture demonstrations and in homework exercises.

The department continues to experiment with novel teaching approaches. A new project, undertaken by professors Miller and Staffilani in collaboration with Professor Warren Seering of the Department of Mechanical Engineering under a grant from the Cambridge-MIT Institute (CMI), will introduce “supervisions” into the standard multivariable calculus subject 18.02, in the style of the University of Cambridge.

### The Major

This spring, the Committee on Curricula gave Institute laboratory credit for 18.821 Project Laboratory in Mathematics, a first in the Mathematics Department. This subject, developed under a grant from CMI, was led first in the spring of 2004 by Professor Michael Artin and again in the spring of 2005 by Haynes Miller. We are working with assessment experts at CMI to quantify how well the course has been meeting its goals. To all appearances, it is very successful in giving students the experience of doing mathematical research in a controlled setting, rather than teaching them the contents of some particular part of mathematics.

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 communication skills into the few courses all our majors take, and (2) the courses most commonly taken by our majors are also taken by a wide range of nonmajors (for whom an added communication-intensive component would not be appropriate). We are moving away from the “tandem subjects,” which are six-unit courses associated with an existing subject. In order to provide time for instruction and practice in communication of mathematics, we are instead emphasizing an expanded series of undergraduate seminars, the project laboratory, and (beginning in the spring of 2006) a version of 18.100

Analysis I, which will be enlarged to a 15-unit subject. In all this, we have been working to control the additional costs.

The group of mathematics majors has never been better. By way of illustration, we have now placed first in the William Lowell Putnam Competition (the major collegiate mathematics competition) twice in succession. We also have been placing among the top teams in the analogous competition in applied mathematics, sponsored by the Consortium for Mathematics and Its Applications.

One of the reasons for the increase in the number of highly talented undergraduates is the very successful participation by the department, under the leadership of Professor Hartley Rogers, in the high school Research Science Institute program. Professor Rogers also directs the unique Summer Program in Undergraduate Research, now funded mainly by the Mathematics Department (following several years of seed money from the dean of science).

**Michael Sipser**  
**Department Head**  
**Professor of Applied Mathematics**

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