Integral

NEWS FROM THE MATHEMATICS DEPARTMENT AT MIT

Dear Friends,

TIME FLIES. Five years ago I was entrusted with the job of "running" our department. That being the usual term for department heads, by now I should have gratefully handed over the reins of leadership to one of my colleagues to carry on with his or her vision for the future. Yet as you can see, I'm still here writing to you. When our dean of science, Marc Kastner, asked me to carry on as head and my colleagues encouraged me to do so, I agreed to renew for a second term. I am proud to continue to serve this great department. I believe in MIT, its values, its extraordinary faculty and our fantastic students. We're privileged to be here. Much has been accomplished. Much remains to do.

People

This year, we're excited to have two outstanding mathematicians joining our faculty. Laurent Demanet has arrived as a new assistant professor of applied mathematics specializing in computational science. Some of his PhD research at Caltech and subsequent work at Stanford involves developing efficient techniques for revealing subterranean Earth structure from measurements of surface earthquake waves. Peter Ozsváth will come here the following fall as a professor of mathematics. A Veblen Prize winner, Peter is well known for his work in low-dimensional geometry and topology.

The most important item on our collective agenda these days continues to be faculty renewal. About a third of our tenured faculty are nearing retirement. Several have already initiated the process. This spring we celebrated Hartley Rogers' 54 years on the MIT faculty at a retirement luncheon for him (see story on page 8). Next year more faculty are planning to retire, including Mike Artin, David Benney, Dan Kleitman, Arthur Mattuck, Dan Stroock and Alar Toomre. The Sputnik-era generation has been the core of our department for a long time. Reconstituting ourselves with a new generation is necessary and healthy, of course, but still it is hard to imagine our department without these extraordinary people. Fortunately, many plan to continue teaching and other activities post-retirement.

Our departmental history book, *Recountings: Conversations with MIT Mathematicians*, has enjoyed tremendous success since its publication last winter. It tells personal stories about science, politics and administration from the 1950s and 1960s. We were most fortunate to have interviewed former department head Ken Hoffman a few months before he passed away, and we were thus able to preserve his remarkable memories along with those of many others.

Finances

The budget cuts stemming from the financial crisis add to our challenges this year. We've been asked to find spending cutbacks of about 15 percent over the next three years. With the fortunate timing of our recently completed fundraiser, Campaign for Math, we've been able to buffer the impact of these cuts significantly. Some reduction in faculty, staff, instructor and graduate student headcount will still be needed, however.

The achievements of the campaign remain intact: support for graduate study so that all 19 incoming graduate students this year are on fellowships, and support for two new endowed professorships—the Leighton Family Chair, awarded to Michel Goemans last year, and the Claude E. Shannon Chair (gift of John and Cynthia Reed), recently awarded to Bjorn Poonen. Fellowships and endowed chairs are key components in our strategy to recruit and retain the very best faculty and graduate students.

Fundraising activities continue unabated. Breakfast talks were held here and in California to showcase the department's research. More talks are planned for this year. One of our goals is to endow the RSI and SPUR summer programs that provide research experiences for high-schoolers and undergraduates. Our RSI students regularly achieve top honors nationally including major scholarships in the Intel and Siemens competitions, as described in our article on student awards on page four. RSI and SPUR have been supported by scarce departmental discretionary funds supplemented by foundation and donor contributions. Endowing these valuable programs would insulate them from competing demands for resources as our budget is reduced.

This spring will see the reconvening of our departmental visiting committee, which will review our programs. These biannual meetings involve lots of work, and we appreciate the efforts of those inside the department and especially the participation of the committee members who devote precious time to this activity.

As always, I'm eager to hear news and thoughts from you. Send them directly to me at sipser@mit.edu. Have a good year!

Michael Sipser
Department Head

New faculty

Peter Ozsváth

Peter Ozsváth, Professor of Mathematics, comes to MIT from Columbia University where he has been a professor since 2004. Ozsváth and his collaborators developed and explored a new class of invariants for characterizing three- and four-dimensional manifolds. In 2007, he received the AMS Oswald Veblen Prize in Geometry for his work in low-dimensional geometry and topology. Ozsváth received his PhD from Princeton under John Morgan in 1994.

Laurent Demanet, Assistant Professor of Mathematics, comes to MIT after three years at Stanford University. He works broadly in scientific computing, applying methods from harmonic and microlocal analysis to seismology and other areas. Demanet received his PhD in 2006 from Caltech in applied and computational mathematics under Emmanuel Candes.

Laurent Demanet

Mathematics at MIT in the post-Sputnik years

By Sarah H. Wright

Recountings: Conversations with MIT Mathematicians, a narrative history of the math department in its formative years, portrays the personal and historical contexts in which its subjects and the department achieved remarkable advances in the field.

Editor Joel Segel devoted three years, some two thousand e-mails and hundreds of hours conducting and editing interviews with a dozen senior MIT mathematicians.

He chose the subtitle, "Conversations," deliberately, he says. "Narrative is a technology like any other, and one particularly suited to capturing inspiration, context, wisdom—intangibles that are crucial to excellence in any real sense."

At first, Segel's subjects weren't so keen on narrative or intangibles, often declaring they had few memories and not much to say, he recalls. "The trick lay in finding the subjects they were most comfortable talking about, from research or teaching, to forgotten byways of department history, to how they themselves became mathematicians," he says.

The result is a volume that offers personal memories, different views on academics and administration, and shows the effects of world events and larger social trends on the science and math communities.

Hartley Rogers, professor emeritus of mathematics, on teaching at MIT pre- and post-Sputnik (1957):

"The nature of the undergraduate body abruptly changed around 1959. When I came to MIT in 1955, I taught elementary sections of calculus. Suddenly, instead of giving three or four As in a freshman section of 25 students, I was giving 10 or 12 As."

Kenneth Hoffman, professor emeritus of mathematics, explaining the department's success:

"Norman [Levinson], like Singer and others … were pushers for *constantly* increasing department standards. Always reach higher and higher. Always try to hire people who are better than you are. They were just relentless about this. And that gets into the air in a place."

Alar Toomre, professor of applied mathematics, on advice for young mathematicians:

"If I were 50 years younger, I'd be looking into biology like mad! I'd look into the mathematics of evolution. Maybe even financial math, damn it."

Arthur Mattuck, professor of mathematics, on having his lectures online through MIT's OpenCourseWare:

"For me, it's a mixed blessing. If I mess up a lecture, I can tell students to look at it on the website. But it also means I have to avoid jokes I made on the web."

"Recountings" also includes interviews with Michael Artin, Harvey Greenspan, Sigurdur Helgason, Steven Kleiman, Daniel Kleitman, Bertram Kostant, Zipporah (Fagi) Levinson, Isadore Singer and Gilbert Strang.
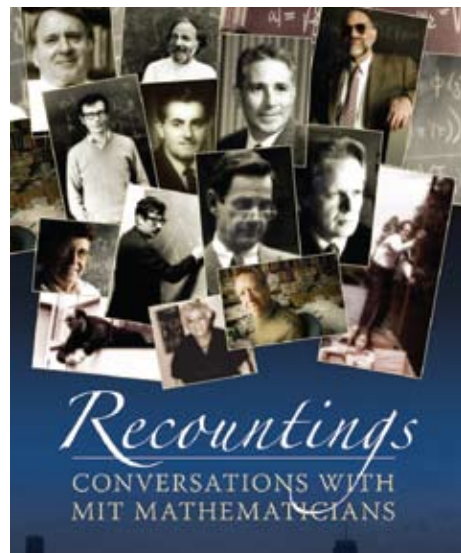
New faculty professorships

George Lusztig has been named the Edward A. Abdun-Nur Professor of Mathematics. The Norbert Wiener Professor of Mathematics since 1999, Lusztig works on geometric representation theory and algebraic groups. In 2008, he was honored with the AMS Leroy P. Steele Prize for Lifetime Achievement, "for entirely reshaping representation theory, and in the process changing much of mathematics."

Professor David Vogan said of Lusztig's contributions, "There are two fundamental and completely different examples in group theory: the 'symmetric group' of permutations of n objects, and the 'linear group' of n by n matrices over a field. Lusztig says the linear group is a quantum version of the symmetric group, with the value of Planck's constant telling you which field you're looking at. He has made that idea precise in a thousand beautiful ways for the past 30 years."

Lusztig joined the MIT faculty in 1978. He graduated from the University of Bucharest in 1968, and received the MA and PhD from Princeton in 1971 under Michael Atiyah and William Browder.

He has received numerous distinctions, including the Junior Berwick Prize of the London Mathematical Society, the AMS Cole Prize in Algebra, and the Brouwer Medal of the Dutch Mathematical Society. Lusztig is a Fellow of the Royal Society, a Fellow of the American Academy of Arts and Sciences and a member of the National Academy of Sciences.

James McKernan has been appointed the Norbert Wiener Professor of Mathematics. McKernan, who works in algebraic geometry, joined the department as professor of mathematics in 2007.

McKernan and his collaborator Christopher Hacon achieved a stunning breakthrough on a famous problem in algebraic geometry concerning the classification of higher-dimensional algebraic varieties. In two papers, one of which was also joint with Caucher Birkar and Paolo Cascini, McKernan and Hacon proved that the canonical ring of any variety is finitely generated. This result largely finishes a project initiated over a century ago by the Italian school of geometry, especially Castelnuovo. It puts into place many of the steps of the minimal model program, whose aim is to understand the birational geometry of any variety, using a sequence of elementary steps known as flips, divisorial contractions and Mori fibre spaces.

For their work, Hacon and McKernan were awarded the 2009 AMS Frank Nelson Cole Prize in Algebra. The award citation states, "The work of Hacon and McKernan has transformed the study of the minimal model program in higher dimensions."

Before coming to MIT, McKernan had faculty appointments at the University of California, Santa Barbara. He received the BA from Trinity College, Cambridge, in 1985, and the PhD from Harvard in 1991 under the direction of Joseph Harris.

Bjorn Poonen has been appointed the Claude E. Shannon Professor of Mathematics. A number theorist working in arithmetic algebraic geometry and computational number theory, Poonen joined the MIT faculty as a full professor in July 2008.

Michael Sipser said, "I first encountered Bjorn a few years ago at MSRI. He gave such a great talk, describing deep, beautiful work and so clearly presented. I wished then and there that we could hire him at MIT. Sometimes wishes come true!"

Poonen received the AB in mathematics and physics from Harvard University in 1989 and the PhD in mathematics from the University of California, Berkeley under Kenneth Ribet in 1994. A former instructor and National Science Foundation fellow at Princeton, he had faculty appointments at UC Berkeley beginning in 1997.

As a Harvard undergraduate, Poonen achieved the top rank of Putnam Fellow on the Putnam Competition four years running, one of only seven people ever to do so. Currently, he is involved with designing new Putnam problems for future exams, which precludes him from coaching MIT students.

Poonen has received many honors, including a Packard Fellowship and a Sloan Research Fellowship. He is the founding managing editor of *Algebra & Number Theory* (2006).

Faculty awards

The following faculty received external recognitions. **James McKernan** received the 2009 AMS Frank Nelson Cole prize in Algebra with his collaborator Christopher Hacon (Utah),

Scott Sheffield

Gilbert Strang

Steven Johnson

for having "transformed the study of the minimal model program in higher dimensions." **Michel Goemans** was elected Fellow of the ACM, **Michael Sipser** Fellow of the American Academy of Arts & Sciences, and **Gilbert Strang** a member of the National

Academy of Sciences. **Scott Sheffield** was awarded an NSF Presidential Early Career Award for Scientists and Engineers. **Benjamin Brubaker, Jonathan Kelner,** and **Katrin Wehrheim** received NSF CAREER awards.

These faculty received MIT internal awards and promotions. **Kiran Kedlaya** received tenure. **Denis Auroux** and **John Bush** were promoted to Professor. **Steven Johnson** was promoted to Associate Professor. **Steven Johnson** received the Edmund F. Kelly Research Award.

Student awards

Hansheng Diao '09 and **Ruitian Lang** '09 received the Jon A. Bucsela Prize in Mathematics for distinguished scholastic achievement, professional promise and enthusiasm for mathematics. **Maria Monks** '10 received the Alice T. Schafer Prize for excellence by an undergraduate woman in mathematics, given by the Association for Women in Mathematics. Honorable mention went to **Doris Dobi** '09.

Maria Monks also received The Barry M. Goldwater Scholarship for outstanding potential in mathematics, natural science or engineering disciplines. Graduate students **Chris Evans**, **Chris Kottke**, **Michael Manapat** and **Angelica Osorno** received the Charles and Holly Housman Award for Excellence in Teaching for their skill and dedication in undergraduate teaching. **Yankı Lekili** received the Charles W. and Jennifer C. Johnson Prize for his outstanding paper accepted for publication. **Alan Deckelbaum** '09 received a 2009 Fannie and John Hertz Foundation fellowship. **Raluca Ada Popa** '09 won the 2009 Outstanding Female Undergraduate Award from the Computing Research Association. For their MIT RSI projects, high-schoolers **Eric Larson** won first prize ($100,000) in the Intel Science Talent Search plus second prize ($50,000) in the Siemens Competition and **Noah Arbesfeld** won sixth prize ($25,000) in the Intel STS.

Yankı Lekili

Angelica Osorno, Chris Kottke and Chris Evans

Doris Dobi and Maria Monks

2009 Doctorates

Salman Abolfathe Beikidezfuli, "Quantum Proof Systems and Entanglement Theory," under Peter Shor. Salman is now a postdoc at Caltech's Institute for Quantum Information.

Jacob Bernstein, "Conformal and Asymptotic Properties of Embedded Genus-g Minimal Surfaces with One End," under Toby Colding. Jacob is now an NSF postdoc at Stanford.

Victor Chen, "The Gowers Norm in the Testing of Boolean Functions," under Madhu Sudan (EECS). Victor is now a postdoc at the Institute for Theoretical Computer Science, Tsinghua University.

Christopher Davis, "The Overconvergent de Rham-Witt Complex," under Kiran Kedlaya. Chris is now at the Max-Planck Institute.

Kyomin Jung, "Approximate Inference: Decomposition Methods with Applications to Networks," under Devavrat Shah (EECS). Kyomin is now an assistant professor at KAIST.

Yankı Lekili, "Broken Lefschetz Fibrations, Lagrangian Matching Invariants and Ozsáth-Szabó invariants," under Denis Auroux. Yankı is now a postdoc at MSRI.

Maksim Maydanskiy, "Exotic Symplectic Manifolds from Lefschetz Fibrations," under Denis Auroux. Maksim is now an NSF postdoc in at Stanford.

Alexander Ritter, "The Novikov Theory for Symplectic Cohomology and Exact Lagrangian Embeddings," under Paul Seidel. Alexander is now a research associate at the University of Cambridge.

Silvia Sabatini, "The Topology of GKM Spaces and GKM Fibrations," under Victor Guillemin. Silvia is now a postdoc at École Polytechnique Fédérale de Lausanne.

Alexey Spiridonov, "Pattern-Avoidance in Binary Fillings of Grid Shapes," under Alex Postnikov. Alexey is now an applied research scientist and software engineer at Facebook.

Liang Xiao, "Nonarchimedean Differential Modules and Ramification Theory," under Kiran Kedlaya. Liang is now a Dickson Instructor at the University of Chicago.

Jingbin Yin, "A q-analogue of Spanning Trees: Nilpotent Transformations over Finite Fields," under Richard Stanley. Jingbin is now in the Global Modeling and Analytics Group, Credit Suisse, New York.

2008 Putnam triumphs

Once more, under the guidance of Professors Hartley Rogers, Richard Stanley and Kiran Kedlaya, our students dominated the top levels in the 2008 William Lowell Putnam Mathematical Competition. An amazing 29 percent of the top scorers (honorable mention and higher) were MIT undergraduates! More details:

- **Putnam Fellows: 2/5** (Bohua Zhan, Yufei Zhao)

- **Next twenty: 5/20** (Thomas Belulovich, Gabriel Bujokas, Qingchun Ren, Colin Sandon and Jacob Steinhardt)

- **Honorable Mentions: 16/54** (Diao, Forbes, Frimu, Hahn, Kishore, Liu, Luo, Mao, Modzelewski, Nampaisarn, Price, Rajagopalan, Sankar, Shao, Trigg, Zamorzaev)

Chuck and Jen Johnson support student excellence

"MIT is cutting edge and has the ability to help shape the world," says Chuck Johnson (CE '55), founder of Visual Numerics, now part of Rogue Wave Software. Chuck and his wife, Jen, have stayed connected to MIT, generously supporting the math department with two important funds that recognize outstanding student work.

In addition to their respect for the Institute, the Johnsons share a "soft spot for MIT and the Boston-Cambridge area," Chuck says. "We were from the Midwest and met here."

When the Johnsons met, Chuck was at MIT earning a degree in Civil Engineering—known back then as Building, Engineering, and Construction—and Jen was attending a small college, now part of Simmons College. The two now live in Racine, Wisconsin.

Mathematics has always been a big interest to Chuck. His father and grandfather were in the construction business so he decided to major in civil engineering at MIT; while here, he took many mathematics classes and got involved in computing. During Chuck's undergraduate years, he recalls being surrounded by mathematicians, including Norbert Wiener, who taught at MIT at the time.

In the 1950s the Project Whirlwind Computer took place, and Chuck's interest in computing turned into a whole career in scientific computing.

"I like to think of mathematics as a hobby of mine," says Chuck. "I belong to a few mathematical societies. I do math crossword puzzles and read math books for pleasure, and my company was in the mathematics business."

Chuck's brother, Millard W. Johnson (PhD '57), encouraged Chuck's interest in math. The brothers were at MIT at the same time and even roomed together. "My brother shared with me Courant and Robbins' *What is Mathematics?* referred to as the Bible for people interested in mathematics, and Gamow's *One Two Three…Infinity: Facts and Speculations of Science,"* he says.

Millard, who passed away this year, was a professor emeritus in mathematics at the University of Wisconsin–Madison.

Today, Chuck's interest is primarily in number theory. He likes Carl Friedrich Gauss' quote, "Mathematics is the queen of the sciences and number theory is the queen of mathematics."

Chuck and Jen have established two funds in the math department: the Charles W. and Jennifer C. Johnson Prize for an outstanding paper accepted for publication in a major journal, and the C.W. (1955) and J.C. Johnson

Jen and Chuck (CE '55) Johnson

PHOTO BY JOHN NIENHUIS

Fund, which supports graduate students in the Department of Mathematics with preference for those with partially funded fellowships from outside agencies. Both funds are a great way to recognize and support outstanding students in mathematics.

Chuck and Jen's philosophy for philanthropy is to concentrate on a few organizations in order to make an impact. They feel that by giving to MIT they're helping to advance science and engineering. A fellow MIT alumnus once said to Chuck that by giving he is actually the one who is receiving, and Chuck says that sometimes he thinks he might be more excited about the gift than the recipient. Jen and Chuck's concentration of support has been to MIT, the Mayo Clinic, and the Racine Zoo. "With these gifts, we cover education, medical and recreation. It has made us happy to support those areas."

Akamai Presidential Fellowships

Started as an MIT research project in the late 1990s and co-founded by mathematics professor Tom Leighton, Akamai Technologies uses mathematical algorithms to speed the delivery of internet content worldwide. In recognition of our department's role in creating this successful company, we award five Akamai Presidential Fellowships annually for first-year graduate study. Fellowship recipient David Jackson-Hanen describes below how this funding has helped him.

"I would like to thank Akamai for providing what has thus far been a terrific experience at

MIT. The availability of full funding for the first year of graduate school, and the corresponding freedom to focus more completely on purely academic pursuits, has been an invaluable resource for myself and other new MIT students.

"Generally, my mathematical interests lie in the areas of differential geometry and topology. As an undergraduate I wrote my senior thesis on gauge theory, in particular the Seiberg-Witten equations on four manifolds. While extensions of that theory are certainly still being very actively studied, it seems to me like some of the most excit-

ing work today is being done in symplectic geometry, and at the moment that is where I am leaning towards directing my interest. One of the wonderful things about MIT's math department is that because geometry and topology are so strong here, with so many people working in different areas, I have the freedom to search around before making a final commitment."

For more information on making a gift to the mathematics department, please contact Director of Development Erin E. McGrath at emcgrath@mit.edu or 617-452-2807.

'Maximal variety' for women in mathematics

By Sarah H. Wright

The Women in Mathematics Lecture Series, held at MIT throughout the spring 2009 semester, explored the diverse and vibrant research being done by women in mathematics. Talks by 10 visiting researchers offered students the opportunity to hear presentations by women mathematicians and to see mathematical research as a viable career option for women.

Katrin Wehrheim, Rockwell International Career Development Assistant Professor of Mathematics, Gigliola Staffilani, Abby Rockefeller Mauzé Professor of Mathematics, and Mia Minnes, CLE Moore Instructor of Mathematics, organized the innovative program.

The series' theme was "maximal variety, from pure algebraic geometry via the mathematics of voting to a meta-mathematics presentation on how to get a PhD in mathematics," said Wehrheim, a leading researcher in low-dimensional and symplectic topology.

"Looking at the students' eyes, I would say each talk was a profound inspiration for at least a few of them," she said, noting that women and men of all ages attended the series.

The lectures were more than talks. The organizers provided pizza following each one, in keeping with their short-term goals of "facilitating interactions between MIT students and the visiting mathematicians and supporting collaborations between the researchers and other women in math at MIT," said Minnes, who works in mathematical logic and theoretical computer science.

Staffilani, an expert in the field of nonlinear partial differential equations, saw the lecture series as a way to show that many women use or study mathematics professionally. If the

support of a conference or lecture makes a difference for one young person, she said, "We should make an effort!"

Longer-term goals will be realized in decades to come, Wehrheim said. "We'll be above the marginalization threshold when a young woman's most natural response to the question 'Why would you major in math?' will be 'I'll become a professor.' "
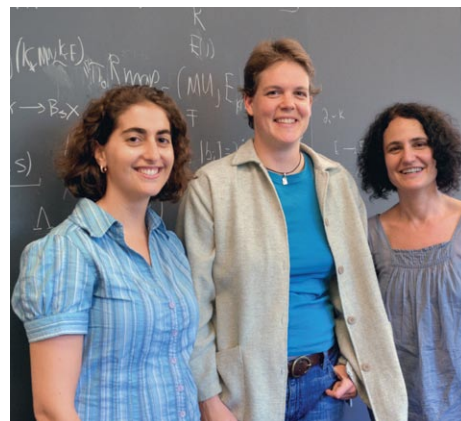
Mia Minnes, Katrin Wehrheim, Gigliola Staffilani

In one talk, Sara Billey (SB '90), professor of mathematics at the University of Washington, discussed the transition from math student to math researcher, emphasizing that finding the right advisor should be a student's "number one academic priority." In a summary of her talk, "How to Get a PhD in Mathematics in a Timely Fashion and What to Do from There," Billey noted, "Your ultimate goal is to push the frontier of mathematics—just a little bit."

The MIT lecture series also featured Susan Landau (PhD '83) of Sun Microsystems; Matilde Lalín of the University of Alberta; Rebecca Weber of Dartmouth; Rina Anno of the University of Chicago; Angela Hicks of the University of California, San Diego; Tai Melcher of the University of Virginia; Ioana Dumitriu of the University of Washington; Andrea Young of the University of Arizona; and Bridget Tenner of DePaul University.

Landau was a co-organizer with Staffilani and Wehrheim of MIT's 2008 Women in Mathematics conference. "That was such an exhilarating experience, we just had to keep it going," Wehrheim said.

The Women in Mathematics Lectures series was funded by the NSF.

To see the full program of talks, please go to http://math.mit.edu/wim.

The Women in Mathematics lecture series is soliciting applications and suggestions for speakers. Junior female researchers with a scientific co-sponsor at MIT can receive up to 50% travel subsidy when giving a generally accessible talk in the lecture series. We also welcome suggestions for high profile speakers on topics suitable for a wider undergraduate audience.

For details see http://math.mit.edu/wim.

2009 Simons Lectures

Étienne Ghys, a specialist in geometry, topology and dynamic systems, and Robert Schapire, a machine learning theorist, presented the Simons Lectures in Mathematics at MIT this year.

Ghys, a senior researcher at CNRS–École Normale Supérieure de Lyon, is widely known for his work on "Dimensions," an online videotext about perceiving four-dimensional objects in three-dimensional space. At MIT he spoke on asymptotic invariants for flows, right-handed vector fields, and on the Rademacher function in lectures titled, "Dynamics in Dimension 3."

Schapire (MS, PhD 1991) is a professor of computer science at Princeton. In "The Boosting Approach to Machine Learning," he discussed the AdaBoost algorithm he introduced with Yoav Freund of Columbia. Short for "adaptive boosting," AdaBoost is an algorithm for statistical analysis in many applications including spam filtering and fraud detection.
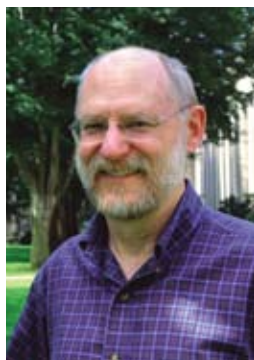
Andrei Okounkov of Princeton and Peter Winkler of Dartmouth will present the 2010 Simons lectures.

Mathematics Project Lab tackles great problems

Want to tackle a problem from an innovative MIT math course?

Try this:

Take a randomly chosen prime number. If it's not 2 or 5, its reciprocal has a repeating decimal expansion. How many digits go by before it repeats? $1/3 = .33333....$ so for $p = 3$ the answer is 1; and $1/7 = .142857142857....$ so for $p = 7$ the answer is 6. In general, the period is a divisor of $(p - 1)$. What are the chances that it is exactly $(p - 1)$?

Haynes Miller

That's an example of the research questions offered students in 18.821, the Project Laboratory in Mathematics, launched in 2004. Last year, some 49 mathematics majors fulfilled their Institute Laboratory Requirement through the math department's Project Laboratory.

Here's another 18.821 challenge: Elsewhere in the universe, many enjoy playing billiards on frictionless pool tables in the shape of equilateral triangles. Without friction, a single shot lasts a long time, and the ball banks against the sides many times. What sequences of side hits are possible?

The Project Laboratory in Mathematics course was designed by professors Michael Artin and Haynes Miller, MacVicar Fellow, and led for the first time by Artin in spring 2004. Since then, Miller and fellow professors Bjorn Poonen, Paul Seidel, David Vogan and Tom Mrowka have led it. Partly inspired by a series of computer explorations in the University of Cambridge Mathematics Tripos, its initial development was funded by a grant from the Cambridge-MIT Institute.

In the course, teams of three students each pick a project from about three dozen options, gather data about the mathematical situation suggested in the project instructions (often but not exclusively by computation), attempt to account mathematically for regularities they observe, and write a formal mathematics paper describing their discoveries. Then they do the same thing again with a second project. And then again: each team works on three projects over the term. Each team gives a presentation of one of their projects to the entire class.

This course is intended to provide students with a glimpse of the research process. There is no syllabus!

Students rave about the 18.821 experience. Senior Survey comments include:

"18.821 was my favorite class at MIT." "Delightful, if intense." "18.821 was a great experience in mathematical exploration." "18.821 allowed me to solve difficult problems that I hadn't encountered before. It taught me how to write mathematics as well." "18.821 is possibly one of the best courses that MIT can offer."

This course—setup and project list alike—is being copied elsewhere. One version has become a permanent part of the University of Michigan program. Another was offered in spring 2009 at the University of California, Berkeley.

The list of possible projects for the course undergoes constant evolution, based on colleagues' suggestions and student feedback. One new candidate project for fall 2009 arose from questions about spontaneous activity in the motor cortex. Another, suggested by Professor Peter Shor, emerged from his work on the computational power of topological quantum field theories.

If you would like to suggest a project yourself, please email hrm@math.mit.edu or seidel@math.mit.edu.

Some thoughts on Lab problems
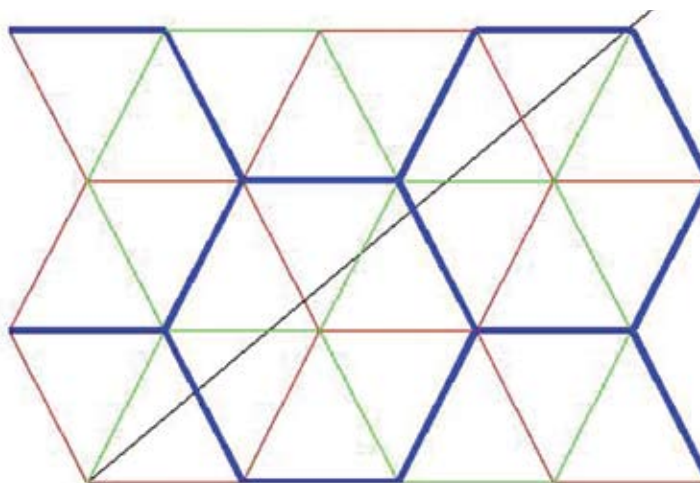
Trajectory plot on triangular table with slope sqrt(3)/2.

The frictionless table problem: The graphic above, by Greg Durrett, Alex Nix and Sara Sheehan, shows a way to think of the billiard trajectory. Imagine the table reflected across each of its sides, then reflected again, and so on: you tile the plane. Snell's law implies that the trajectory corresponds to a straight line on the plane. Continuing with this line of thought, the problem translates to a question about continued fractions. If the table wasn't equilateral, or was, say, a pentagon, the problem becomes much harder and the answer is for the most part unknown.

The randomly chosen prime number: The probability that $1/p$ has period $(p - 1)$ is about 37 percent. This was observed and explained on probabilistic grounds by Emil Artin in 1931. It has never been proven, though it is known to follow from the celebrated Riemann Hypothesis. Students often rediscover Artin's argument and investigate related problems—how often is the period $(p - 1)/2$? What if expand using base 7 instead of base 10?

Celebrating Singer at '60 mod 25'

By Sarah H. Wright

Colleagues, friends and students celebrated Institute Professor Isadore Singer's 85th birthday and his legendary contributions to mathematics and physics with a two-day conference, Perspectives in Mathematics and Physics, held May 22-24 at MIT and Harvard.

Singer first joined the MIT mathematics faculty in 1950; he specializes in differential geometry, partial differential equations and mathematical physics. A 1983 winner of the National Medal of Science, Singer shared the 2004 Abel Prize, the highest distinction for a senior mathematician, with Sir Michael Atiyah, University of Edinburgh, for their discovery and proof in 1962 of the Atiyah-Singer Index Theorem. The two were praised for bringing together topology, geometry and analysis, and for their outstanding role in building new bridges between mathematics and theoretical physics.

Rosemarie and Is Singer

MIT President Susan Hockfield opened the conference, introducing Singer as a renowned member of the MIT faculty whose work has altered the very landscape of his profession.

"He represents the very best of the Institute. As both scholar and teacher, he combines the highest rigor with a spirit of boldness, experimentation and fearlessness in reaching across disciplines," Hockfield said.

Atiyah gave the first of the weekend's 15 talks honoring Singer. According to Atiyah, their famed five-decade relationship has been mutually instructive: Singer taught Atiyah functional analysis, differential geometry and physics. "He learned algebraic geometry from me," Atiyah said.

The celebratory weekend included a birthday dinner, complete with cake and toasts to life-long friendships, held at the American Academy of Arts and Sciences. In a brief speech, Singer described himself as age 60, not 85, igniting a recurring joke that the honoree's true age was "60 mod 25."

Tom Mrowka organized the event with Harvard's S.T. Yau. Funding for Perspectives in Mathematics and Physics was provided by MIT and Harvard and by the Simons Foundation.

Jim Simons, Marc Kastner, Is Singer, Susan Hockfield and Michael Sipser

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Hartley Rogers retires

Over 50 faculty, family, friends and members of the administration celebrated Professor Hartley Rogers' 54 years at MIT with a retirement luncheon May 19 at the Faculty Club. Many spoke about his major involvement during the 1960s in setting MIT's educational policy and on handling student unrest, and about his MIT service during the 1970s as associate provost, chair of the faculty and chair of the MIT Press. Others described his commitment to education, many years of lecturing 18.02 Calculus and coaching the Putnam competition, and his creating the SPUR and RSI summer research programs in mathematics still active today.

Rogers received his PhD from Princeton under Alonzo Church in 1952 and became a major figure in mathematical logic. He brought Gerald Sacks to MIT and together they built MIT into the major center for logic worldwide. Rogers' influential book, *Theory of Recursive Functions and Effective Computability*, was required reading for everyone in the budding field of theoretical computer science.

Remembering Ken Hoffman

Former Department of Mathematics Head Kenneth M. Hoffman, who spent more than 40 years on MIT's faculty and made significant contributions to U.S. education and science policy, died September 29, 2008. He was 77.

Hoffman led the math department from 1971 to 1979, retiring in 1996. His area of research specialization was functional analysis, and he made fundamental contributions to both complex and abstract analysis.

Devoted to public service and education, Hoffman received the Joint Policy Board for Mathematics' first Public Service Award and the first Award for Distinguished Public Service of the American Mathematical Society.