MATH MATTERS

DEPARTMENT OF MATHEMATICS ♦ CORNELL UNIVERSITY ♦ ITHACA NY NOVEMBER 2005

LETTER FROM THE CHAIR, KENNETH S. BROWN

"Why should I take trigonometry? I'll never use this stuff." That was the beginning of a conversation I had with my son when he was in high school. He's now 38 years old and recently reminded me of the feeble answer I gave him at the time: "You'll need it for calculus." You can guess what question he asked next.

Now, more than 20 years later, he isn't yet convinced that he benefitted from taking trig and then calculus. After all, he doesn't use it in his work. If I could go back 20 years, I think I would still tell him he should study trig (and calculus, and art, and music, and literature, and history, and biology,...). I'm not sure that I would be any more eloquent the second time around in explaining why he should learn all these things.

Are you now glad Cornell required you to take a variety of courses whose value you couldn't appreciate at the time? I would love to hear your answers. Please e-mail your thoughts to me (kbrown@math.cornell.edu); I'll compile them and make them available on our web page. I'm especially interested in your views about the Math courses that you took, but I'd also like to hear what you think about a liberal education in general.

If you want to see answers written by professionals (concerning math specifically), listed below are some sources that were put together by Dave Bock who taught math at Ithaca High and is now a Senior Lecturer here.

•"Mathematical Moments" is a series of posters that promote appreciation and understanding of the role math plays in science, nature, technology, and human culture. Some of the topics are the internet, fingerprints, animation, robots, weather forecasting, voting, medicine, DNA, and music. The posters can be found at www.ams.org/mathmoments.

•In the "Careers in Mathematics" video, mathematicians working in industry, business, and government describe what their day-to-day work lives are like and how their backgrounds in mathematics contribute to their jobs. See www.msri.org/ext/CareersInMathematics.html .

•"Mathematics is Everywhere" offers illustrated math puzzles dealing with such applications as soccer balls, violin strings, and astronomy. It's available at www.pims.math.ca/education/everywhere .

In last year's *Math Matters*, I wrote about our external review and our first ever department retreat, which resulted in a hiring plan. We have now gone through our first season of trying to implement that plan, as well as our second annual retreat, and I am very pleased with our progress to date. We successfully recruited a distinguished young logician, Greg Hjorth, who will be joining us as a full professor on January 1, 2006. Greg got his Ph.D. at Berkeley in 1993 and has received many awards and honors since then. We are delighted that he is joining the department.

We also hired a new assistant professor, Tara Holm, who works in symplectic geometry. Tara's appointment began July 1, 2005, and she is taking her first year on leave at the University of Connecticut. We look forward to having her here in Ithaca starting next year.

Yuri Berest, who has been in the department as an assistant professor since 1999, was promoted to associate professor with tenure as of July 1, 2005. It is a pleasure to welcome Yuri to the tenured faculty. We have also reappointed two of our current assistant professors, Camil Muscalu and Ed Swartz, to second three-year terms starting July 1, 2006. The future of the department depends on our ability to keep recruiting and retaining outstanding young mathematicians like these.

Our focus this year is a continuing effort to replace José (Chepe) Escobar, who died in January 2004 (see *Math Matters* November 2004). Chepe worked in an important area of mathematics called geometric analysis. I hope you will read in next year's *Math Matters* that we have successfully recruited an exceptional young geometric analyst.

You will notice a new section in this issue of *Math Matters*, devoted to alumni news (see page 5). We hope to hear from many more of you for next year's issue.

This is my last "letter from the chair". I am stepping down next summer, and Dan Barbasch will take over as chair July 1. It has been a privilege to serve this fine department for four years.

Honors & Awards

Fellow of the American Academy of Arts & Sciences


Gregory Lawler

In April 2005, the Academy of Arts & Sciences announced the election of 196 new Fellows for 2005, which included Professor **Gregory Lawler.**

Greg joins his fellow Cornell colleagues elected to the Academy: Leonard Gross (2004), Richard Durrett (2002), Harry Kesten (1999), Eugene Dynkin (1978), and William Thurston (1978).

Sloan Research Fellowship Awarded to Camil Muscalu

Assistant Professor **Camil Muscalu** received an Alfred P. Sloan Foundation Research Fellowship this year. His area of research is harmonic analysis and partial differential equations. He joins a long list of fellow Cornell Mathematics faculty receiving this prestigious award.


Camil Muscalu

More news: www.math.cornell.edu/News/2004-2005/newsarchive.html .

International Congress of Mathematicians

Professors **Birgit Speh** and **Karen Vogtmann** and former graduate student **Martin Bridson** have been invited to address the International Congress of Mathematicians, to be held in August 2006 in Madrid, Spain.

The ICM, held every four years, is attended by thousands of mathematicians from around the world.

John Hubbard Honored at Conference

A conference entitled Conformal Dynamics, Hyperbolic Geometry, and Continued Fractions was held in France in June 2005 in honor of Professor **John Hubbard**.

Cornellians attending this event and giving talks included Professor John Smillie and graduate students Joshua Bowman, Sarah Koch, Gregory Muller, Matthew Noonan, and Roland Roeder. A number of Fields Medalists and many other distinguished mathematicians from around the world attended the conference.

Russell Teaching Award


Maria Terrell

Senior Lecturer **Maria Terrell** received a Stephen & Margery Russell Distinguished Teaching Award from the College of Arts & Sciences in May 2005.

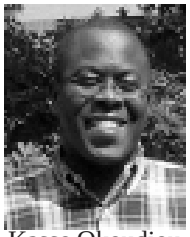
Annual Department Awards

The 2004 Department awards were presented at our holiday party.

Teaching Awards: senior faculty **Leonard Gross**, junior faculty **Tara Brendle** and **Kasso Okoudjou**, and teaching assistant **Heather Armstrong**.


Leonard Gross


Tara Brendle


Kasso Okoudjou


Heather Armstrong

Additional Graduate Student awards presented at the party were:

Robert John Battig Prize: **Antonio Montalban** and **Roland Roeder**.

Eleanor Norton York Award: **Jeffrey Mermin**.

Hutchinson Fellowships: **Drew Armstrong** and **Treven Wall**.

Antonio Montalban wins Sacks Award

The Sacks Prize was awarded to **Antonio Montalban** for 2005. The prize is awarded for the most outstanding doctoral dissertation in mathematical logic world-wide. Antonio received his Ph.D. in August under the direction of Richard Shore.

Can You Do Sudoku?

by Rick Durrett

Sudoku, the Japanese word for single digit number, is the name of a puzzle that became a craze in Japan in 1984 and finally made it to the U.S. in April 2005. It is now carried by more than half of the newspapers in the country. The Syracuse paper and USA Today have been carrying the puzzle since the summer. Around Columbus Day, the Ithaca Journal discovered that it motivates people to read the classified ads, so you can find it there. If you don't want to buy a paper or walk to the Trillium where there are lots of "free for students" copies of USA Today, you can find the puzzles online at usatoday.com/sudoku/index.html. The goal is to fill in the grid so that every row, column, and nine 3x3 boxes bounded by dark lines contain the numbers 1 to 9 with no repeats. Without the last condition they would be Latin squares invented by Leonhard Euler in 1783. There are 6,670,903,752,021,072,936,960, or 6.67×10^{21}, ways of filling in a blank Sudoku grid (proof left to the reader), so there is an almost endless supply of puzzles.

Like crossword puzzles, Sudoku puzzles in USA Today get harder as the week progresses. The example here is from a Monday USA Today, so it is a one star. 37 numbers are given which is considerably more generous than the two dozen you usually find in the five star puzzles in the Sunday Syracuse paper. The number of puzzles is $9^{22.78}$, so generically you need 23 numbers to have a unique solution.

Sudoku puzzles always have a unique solution, which means that you can use logic to figure out all of the numbers. The first and simplest type of reasoning is to note that there is a 1 in the first row and a 1 in the second row, so the one in the top right 3x3 box must be in the third row. It can't be in the 7th column since there is already a 3 there, or in the 8th because there is already a 1 in that column, so it must be in the 9th column.

Turning the last reasoning around, when you see a box without a 1, look at the rows and columns that lead into it. This will tell you that position (8,5), i.e., row 8 and column 5 must be a 1. Similarly, (7,1), and (6,3) must be 1's, and we have put all nine 1's in the puzzle. Continuing through the numbers 2 to 9, and cycling through them several times, you can fill in a lot of the puzzle, but eventually you need more subtle clues.

Sometimes you can only narrow the location down to two possibilities. For example, the presence of a 2 in the 5th column and in the first row tells us that the 2 in the top middle box must be in (2,6) or (3,6). Put a little 2 in the top left of each box to indicate this. We don't know exactly where the 2 is, but it is in the 6th column so the 2 in the bottom middle box must be in the 4th column. This isn't helpful yet but it will be later.

The 4's in the 5th column and the 1st row tells us that the 4 in the top middle box must be in (2,6) or (3,6). When we put a little 4 in the top left of each box to indicate this, we see 2,4 in each of the two boxes. Since these two numbers must go in these two boxes, no other number can go in these boxes.

When the puzzle gets filled up, you can make inferences based on what is missing. For example, if you have eight numbers in a row, column, or box, then you know what the last one must be. This is often useful when there are seven or fewer numbers. For example, the 5th column is missing 1, 5, 6, and 9, but 1, 5, and 6 are already in the second row so (2,5) must be a 9.

These rules are enough to solve our example and most that are three stars and under. Harder puzzles require more subtle inferences and this is what makes them fun. As in mathematics, sometimes the proof breaks down into cases. For example you can resolve our 2,4 situation in one of two ways. Rather than guess and have a 50% chance of being wrong, you can write 2/4 and 4/2 in the boxes to indicate the two cases and work out the consequences until one possibility runs into a contradiction.

The final bit of advice is to be very careful as you work. There is nothing worse than working on a puzzle for half an hour and then finding you have two 8's in one row or have come to an impossible situation. If you put the wrong word in a crossword puzzle you can repair it, but if you get a wrong number in Sudoku, you are better off to start again or try another puzzle.

	1	2	3			4		
5			1			6		7
8			5	7		3		
6	7			8			1	
	3		7	4	1		5	
	9			2			7	3
		7		3	6			9
3		4			9			8
		6			7	1	3	

(Answer on page 7.)

Research Experiences for Undergraduates

by Bob Strichartz, Tara Brendle, & Martin Kassabov

The Department of Mathematics has been running a Research Experiences for Undergraduates (REU) Program every summer since 1994. With support from the National Science Foundation, this program brings talented students here from across the country to spend eight weeks working on research projects directed by faculty members. Summer 2005 had projects in Analysis on Fractals, led by Bob Strichartz (REU Program Director) and assisted by graduate student Jessica Zuniga, Mapping Class Groups and Topology of Surfaces, led by Tara Brendle and assisted by graduate student Heather Armstrong, and Expander Graphs and Groups, led by Martin Kassabov and assisted by graduate student Francesco Matucci. A lively and productive group of fifteen students battled with challenging problems and made many interesting discoveries. Two of the students came with funding from their home colleges, and our department supported one student. Many of the students are continuing to work on their projects, and several papers reporting the results are in the works.

The **Analysis on Fractals** group arrived a week early to attend the Conference on Analysis and Probability on Fractals (see article page 5) for a crash course on the subject and a quick glimpse of some of the accomplishments of previous groups of REU students who have been working in this area since 1996. With this head start, they were able to jump into work on four topics.

Carlos Avenancio-Leon (U. of Puerto Rico-Humacao) studied local properties of harmonic functions on the Sierpinski gasket (SG) in a neighborhood of a periodic point. He was following up on work by REU students from 2003, covering the case when a certain matrix has complex conjugate eigenvalues.

Jonas Azzam (U. of Nebraska-Lincoln) and Michael Hall (U. of Maryland) began work on understanding the analog of conformal geometry in the fractal setting. They were able to compute the spectrum of some conformal Laplacians on SG and found a very beautiful differential equation satisfied by effective resistances for conformal energies. This differential equation involves energy measures, so their work turned in another direction and led to an interesting linear algorithm for computing these measures (the definition involves quadratic expressions).

Mihai Cucuringu (Hiram College) studied an infinitesimal version of the effective resistance metric on SG. He was able to construct and analyze a dynamical system that models this problem, and so prove existence and find an algorithm to compute this metric. He also studied a related problem, how to describe all self-similar energies on SG. C. Sabot solved this problem in 1997 in a long paper with a very complicated solution. Mihai showed that by adding some twists to the definition of self-similarity, the solution becomes much simpler. Tyrus Berry (U. of Virginia) worked on a new approach to computing the spectrum of a fractal Laplacian called "outer approximation". The idea is to approximate the fractal by a sequence of domains in the plane that contain it, and then take a renormalized limit of the spectra of the ordinary Laplacians on the domains. Along the way, Tyrus made a remarkable serendipitous discovery. While looking at the eigenfunctions of the Laplacian on a rather simple sawtooth-shaped domain (approximating an interval), he noticed that some of them appeared to be highly localized to one of the teeth, and close to zero on the other teeth. (Of course, it cannot be identically zero.) The existence of localized eigenfunctions of fractal Laplacians has been one of the surprising features of the theory. It is interesting that it spills over to ordinary Laplacians on domains that are very far from being fractal.

The **Mapping Class Groups and Topology of Surfaces** students worked on three different projects, all related to the *Torelli group* of a surface (the subgroup of the surface mapping class group acting trivially on homology) and a certain subgroup of Torelli known as the *Johnson subgroup*.

Two students—Thomas Church (Cornell) and Aaron Pixton (Princeton)—studied the *Magnus representation* of the Torelli group. In particular, they generalized and gave new proofs of some results of Suzuki that interpret the Magnus representation topologically in terms of "higher intersection forms" on the relative homology of the universal abelian cover of a surface. Their results appear to give a new abelian quotient of the Johnson kernel, whose abelianization is currently unknown.

Three other students worked on another homomorphism of the Torelli group known as the Birman-Craggs-Johnson homomorphism. Tova Brown (UC Santa Cruz) worked on finding a new topological characterization of the kernel of this map. Peter Maceli (Cornell) and Vijay Ravikumar (Amherst College) studied the action on second homology groups induced by the BCJ map, in particular using the method of abelian cycles. This yielded an improvement on known lower

bounds for the rank of the second homology of the Torelli group. Vijay also studied the cokernel of this induced map, suggesting a new characterization of elements "missed" by the abelian cycles method.

There were six students participating in the project on **Expander Graphs and Groups**. Finite graphs with nice properties like symmetry, low diameter, and high connectivity have many applications. Such graphs are called expanders and they are often used as basic building blocks of various computer and communication networks. Typically one is looking for graphs with many vertices (large networks), and as few edges as possible (low cost).

The students—Mihai Cucuringu (Hiram College), Alina Florescu (Mount Holyoke College), James Davis (North Carolina State), John Hegeman (Stanford), Hyun Kyu Kim (Cornell), and Lauren Susoeff (Beloit College)—worked together on several projects using various methods from group theory to construct and study interesting examples of finite graphs.

One of the projects was focused on studying the diameters of Cayley graph. The students learned many combinatorial tools and successfully applied them to several problems. The work on this project lead to fast algorithms for finding shorts paths in some Cayley graphs of finite simple groups. These algorithms are likely to be used in many practical applications of these graphs in theoretical computer science.

Another project was aimed at understanding the Kazhdan constants of finite groups with respect to different generating sets. The project started with a mini-course in representation theory. The students not only understood several recent results, they were also able to generalize a theorem of Alon-Roichman about existence of small expanding generating sets in groups.

Summer 2006 projects will be Analysis on Fractals (Bob Strichartz), Dynamical Systems (Sarah Day), and Geometric Combinatorics (Ed Swartz).

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Alum News

Yong-Suk David Cho, B.A. Mathematics 2004, is a System Development Consultant with the Korea Financial Engineering & Consulting Co., LT. in Seoul, Korea. E-mails: yc232@cornell.edu, cornellian@catchivy.com, or catchlife@gmail.com.

Jonathan Insler, B.A. Mathematics/Physics 2003, is a Ph.D. candidate in particle physics at the University of Rochester. He spent the summer of 2004 at Cornell in the Wilson Lab and expects to return here again with the Rochester group. Jon's e-mail address is jinsler@pas.rochester.edu.

Please contact us, and give us some news! mathmail@cornell.edu

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Analysis and Probability on Fractals

The second Conference on Analysis and Probability on Fractals was held at Cornell May 31-June 4, bringing together 65 participants from around the world. The organizing committee included **Bob Strichartz** and former graduate student **Alexander Teplyaev**.

See Annual Report 2004-2005, page 35, for more information.

Former Faculty News

2005 Kieval Lecture

Persi Diaconis

Professor **Persi Diaconis**, formerly David Duncan Professor of Mathematics at Cornell, delivered the Kieval Lecture on September 14. Faculty, graduate and undergraduate students, and staff crowded Bache Auditorium to be entertained by his talk *Mathematics and Magic Tricks*.

Peter Hilton Delivers Oliver Club Lecture

On October 13, **Peter J. Hilton**, Distinguished Professor Emeritus of Binghamton University, spoke in our Oliver Club on *Breaking high-grade German ciphers in World War II*. The audience found the lecture extremely interesting. Professor Hilton was a member of our faculty July 1962-June 1971.

Kyoto Prize Awarded

Simon A. Levin, Professor of Biology at Princeton University, was awarded the 2005 Kyoto Prize in Basic Sciences. Professor Levin began his career as Assistant Professor in our department in 1965. He spent 27 years at Cornell, mostly in Ecology & Evolutionary Biology, before moving to Princeton.

VIGRE Programs at Ithaca High School

by Rick Durrett and Ed Swartz

We continued our high school outreach activities using a combination of department funds and our VIGRE grant. After two years as coordinator, Rick Durrett turned control over to Ed Swartz for the Academic Year 2005-2006.

The **Math Explorer's Club (MEC)** enters its third year of operation and meets at Ithaca High School in the 2:45-3:30 time slot set aside for after-school clubs. Activities are organized into six- to eight-week modules, each of which is devoted to a specific topic.

Antonio Montalban and Yannet Interian-Fernandez began Spring 2005 by introducing the students to a wide variety of puzzles: metal objects and/or strings that were linked together but could be separated if you were clever about it, liars and truth-tellers puzzles, Rubik's cube in the 3x3x3 and 2x2x2 forms, and computer based puzzles they found on the world wide web.

Chris Lipa continued with a six-week computer exploration of dynamical systems and chaos, using the laptops to run a number of Java applets and games from Bob Devaney's homepage math.bu.edu/people/bob/. Radu Murgescu led an exploration of number theory in the last six weeks. He began the module with a collection of number puzzles that he copied from various sources for the students to work on individually or in groups. After that, he taught the students some of the basic properties of modulo arithmetic and challenged the students to produce proofs of elementary facts.

The club moved from Thursdays to Wednesdays this fall. Thus far, Sarah Koch has shown them the game Set, strategies for fair cake division, and De Bruijn sequences á la Persi Diaconis. Next up is Jessica Zuniga who will lead a module on probability and related topics.

Senior Seminar is entering its fourth year of operation and is a class on advanced mathematics designed for students who have taken most of the math classes available at Ithaca High School. It meets for one period (45 minutes) during school hours on Monday, Wednesday, and Friday and introduces students to topics they would typically not see until their junior or senior years in college.

Jeff Mermin, Jason Martin, and Deena Schmidt organized the seminar during the 2004-2005 Academic Year. Jeff focused on elementary properties of continued fractions: how they provide "best" rational approximations to real numbers and are closely related to the Euclidean algorithm. A series of diversions led to a discussion of the definition of limits, the real and *p*-adic numbers, and infinite cardinals. Jason began with basic substitution ciphers and then moved to poly-alphabetic substitution ciphers. From there, the group investigated linear feedback shift registers, stream ciphers, and finally block ciphers. Deena focused on applications of probability theory ranging from gambling to genetics. Concepts were introduced with lots of examples, and students worked though challenging problems in class.

With help from the organizers, students concluded the year by researching and presenting topics of their choice. Some of the projects included differential cryptanalysis, the ENIGMA machine, group theory, the P vs. NP problem, and an extension of continued fractions to provide better approximations. At least one student independently produced existing results, and two students wrote a computer program to play poker that was entirely original and quite impressive.

This fall, there are about ten students participating in the seminar. Matt Noonan taught the first module on various notions of infinity. They started with uncountability in set theory and used the continuum hypothesis to start thinking about other models of the "standard" mathematical universe. This led to a discussion of nonstandard reals and later hyperbolic and projective geometry (as "nonstandard" models of Euclid's first four axioms). They talked about the quaternions so that they could comb the 3-sphere. Other geometric ideas, such as the Banach-Tarski paradox, which linked back to the axioms of set theory, were discussed. They also saw how infinite techniques could be applied to finite problems in combinatorics through the theory of structure types, which seem to have fractional (or even complex!) cardinality.

The second module is being taught by Jeff Mermin. They will discuss flaws in existing voting systems used in American elections, instant Runoff Voting (used in municipalities and foreign countries), and Borda Count (widely used in sports). He will also prove Arrow's Impossibility theorem, which states that every voting system is flawed, and examine measurements of voting power and issues of apportionment.

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The Class of 2005

Math Majors

Commencement was held May 29, 2005. Fifty-one mathematics majors (including two in August 2004) received Bachelor of Arts degrees, with nineteen graduates awarded honors in mathematics:

Summa Cum Laude

Vorrapan Chandee
Timothy Dampman DeVries
Shawn Luebke Drenning
Michael Vincent Jennings

Magna Cum Laude

Saúl Antonio Blanco Rodríguez
Mushfeq Ahmed Khan*

Cum Laude

Daniel John Campbell
Saifon Chaturantabut
Nan Gu
Daanish Hasan
Avishek Hazrachoudhury**
Seung Won Lee
Andrew Jonathan Marks
Scott Gregory McCalla
Philip Douglas Rant**
Hannah Snow Seidel
David Alan Siegel
Tomohiko Tanabe
Haicheng Wang

*August 2004 degree
**January degree

Harry S. Kieval Prize

The *Kieval Prize*, given to outstanding graduating majors, was awarded to **Vorrapan Chandee**, **Timothy DeVries**, **Shawn Drenning**, and **Michael Jennings** for 2005.

Graduate Students Awarded Ph.D.'s

Maria (Sloughter) Belk, *Applications of Stress Theory: Realizing Graphs and Kneser-Poulsen*, August.

Nathanael Berestycki, *Phase Transitions for the Distance of Random Walks with Applications to Genome Rearrangements*, August.

Lee Gibson, *The Number of Sites Visited by a Random Walk on an Infinite Graph*, August.

Radu Haiduc, *Horseshoes in the Forced van der Pol Equation*, August.

Spencer Hamblen, *Lifting n-dimensional Galois Representations*, August.

Christopher Hardin, *The Horn Theory of Relational Kleene Algebra*, August.

Todd Kemp, *Hypercontractivity in Non-commutative Holomorphic Spaces*, August.

Antonio Montalban, *Beyond the Arithmetic*, August.

Roland Roeder, *Topology for the Basins of Attraction of Newton's Method in Two Complex Variables*, August.

Hasanjan Sayit, *Realistic no Arbitrage Conditions*, August.

Serguei Slavnov, *Semantic Investigations of Linear Logic*, August.

Fernando Schwartz, *Scalar Curvature Problems on Manifolds with Boundary*, May.

José Trujillo Ferreras, *The Random Walk Loop Soup and the Expected Area of the Brownian Loop in the Plane*, August.

Russell Woodroofe, *Shelling the Coset Poset*, August.

The annual **William Lowell Putnam Competition** will be held December 3. For information, see www.math.cornell.edu/Undergraduate/contests.html .

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Answer to Sudoku Puzzle

712368495
543192687
869574321
675983214
238741956
491625873
127836549
354219768
986457132

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The **CMCM** was held November 11-15. For contest results, go to www.math.cornell.edu/%7Emcm/.

Math Matters is published through the combined efforts of members of the department. My thanks go out to Tara Brendle, Ken Brown, Rick Durrett, Bill Gilligan, Arletta Havlik, Joy Jones, Martin Kassabov, Michelle Klinger, Donna Smith, Bob Strichartz, and Ed Swartz for their contributions.

Catherine Stevens, Editor

Mathematics Department Endowments & Gifts

We are grateful to alumni, friends, and family who support our endowments or provide other gifts and donations to the department. Without their generosity, we would be unable to provide many of the offerings that make our department unique.

The **Chelluri Lecture Series** was established by Raju Chelluri's parents in his memory. Funds will be used to invite distinguished mathematicians to give annual lectures.

The **Michael D. Morley Senior Prize in Mathematics** is presented annually to an Ithaca High School student who has excelled in mathematics and who has demonstrated originality and innovative power in mathematics.

Teaching awards for graduate students and faculty were created in 2001. We would like to endow the **Teaching Award for Graduate Students** so that a generous prize can accompany it.

The **Colloquium Endowment Fund** was instituted to invite distinguished scientists to speak at the Oliver Club seminars. The Oliver Club was founded in January 1891 by James E. Oliver. (See www.math.cornell.edu/~oliver/.)

The **Eleanor Norton York Endowment** was established in honor of Eleanor Norton York to recognize outstanding graduate students in both Astronomy and Mathematics. The income from this endowment is used to provide annual prizes to a continuing graduate student.

The **Faculty Book Endowment** is dedicated to the goal of providing the Cornell community with immediate access to one of the world's finest collections of mathematics books and publications.

The **Israel Berstein Memorial Fund** was established in honor of Israel Berstein, a professor in this department from 1962-1991. The memorial fund is intended to help young mathematicians in the field of topology.

The **Logic Endowment** was started with a generous gift from a former Cornell undergraduate. This endowment seeks to actively support promising logic students.

The **Robert John Battig Endowment** was established by his parents after his untimely death. Robert was awarded a January 1998 Ph.D. in mathematics. The fund provides an annual prize to an outstanding continuing graduate student in mathematics at Cornell.

If you would like to contribute to any of these endowments, please make your check payable to Cornell University. Indicate on the check the specific endowment or that it is a gift in support of the Department of Mathematics, and send it to:

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