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Newsletter

Courant Institute of Mathematical Sciences

Departments of Mathematics and Computer Science, and the Center for Atmosphere-Ocean Science at New York University

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Mikhael Gromov Receives the 2009 Abel Prize

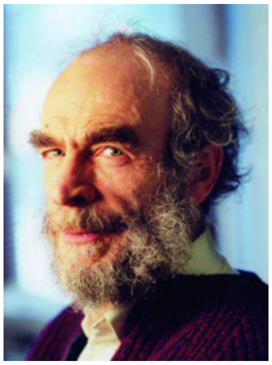

Photo: Gérard Uferas

The Norwegian Academy of Science and Letters awarded the 2009 Abel Prize to Mikhael Gromov, the Courant Institute's Jay Gould Professor of Mathematics, "for his revolutionary contributions to geometry." Gromov will receive the Prize from His Majesty, King Harald V of Norway, in Oslo on May 19th.

Gromov obtained his Masters degree (1965), his Doctorate (1969) and his Post-doctoral Thesis (1973) from Leningrad University. His doctoral advisor was Vladimir A. Rokhlin. Before joining Courant, Gromov held professorial positions at Leningrad University, the State University of New York at Stony Brook, and the Université de Paris VI, and he currently also holds a Professorship at the Institut des Hautes Études Scientifiques. He has received many other prestigious awards, recently including the János Bolyai Prize from the Hungarian Academy of Sciences (2005), the Frederic Esser Nemmers Prize in Mathematics (2004), the Kyoto Prize in Basic Sciences (2002), and the Balzan Prize (1999).

According to the Norwegian Academy, Gromov's work has led to "some of the most important developments [in geometry], producing profoundly original general ideas, which have resulted in new perspectives on geometry and other areas of mathematics." Courant Director Leslie Greengard said that Gromov "has been an inspiration to colleagues and students here and to mathematicians around the world. His unique viewpoint has revolutionized geometry, topology, group theory and their interplay. The honor is richly deserved." "The work of Gromov," writes the Norwegian Academy, "will continue to be a source of inspiration for many future mathematical discoveries."

Gromov is the third Courant mathematician to receive the Abel Prize in five years; it was awarded to Professor Emeritus Peter Lax in 2005, and to Professor Raghu Varadhan in 2007.

The Story of the Poincaré Conjecture

Or when is a Proof a Proof? by M.L. Ball

This has long been a source of puzzlement to many an undergraduate student; it can also be a deep philosophical question. Here, we take the pragmatic view that a proof is truly a proof when it is recognized as such by the mathematics community. This brings us to the tale of the Poincaré conjecture, explained with the help of Mathematics Professor Bruce Kleiner.

Kleiner joined the Courant Institute this September as a new faculty member. He is originally from Seattle and comes to Courant by way of Yale, the University of Michigan, and Berkeley.

Formulated approximately 100 years ago, the Poincaré conjecture was one of the most famous unsolved problems in mathematics. Not only was it a central question in topology, it was a question that many very well known mathematicians had tried to solve – unsuccessfully. Then in the 1980s came a breakthrough. A mathematician named Richard Hamilton introduced the Ricci flow, a completely new way to attack the Poincaré conjecture. If it was successful, he theorized, it would prove not just the Poincaré conjecture but also the geometrization conjecture, which among other things implies the Poincaré conjecture.

This was big news in itself, but in November 2002 something truly remarkable happened: Grigori Perelman, a widely respected Russian mathematician, posted a paper on a pre-print server. According to Kleiner, "When a mathematician writes a paper, instead of mailing it out to people, he or she now posts it on Arxiv, a central repository of pre-prints, which anyone around the world can access anytime. Overnight, a huge number of people became aware of the fact that Perelman had posted this preprint. In it, he developed a number of new tools for studying the Ricci flow and claimed that by using these, he could prove the geometrization conjecture.

"This was really an extraordinary development in many respects because first of all, someone was claiming to prove the geometrization conjecture. Not only that, but since 1994, Perelman had been living in St. Petersburg following a fellowship at Berkeley. He had published essentially nothing and had virtually withdrawn from the mathematical community. In early 2003,

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(Poincaré Conjecture) continued from page 1

Perelman posted a second pre-print which completed the program he had alluded to in the first paper. This was all rather spectacular."

Nevertheless, experts in the field had a great deal of trouble reading Perelman's papers because they were not written in the traditional format. Kleiner says that they could not have been submitted to a reputable journal and been accepted – there was way too much missing. By and large, they were not given serious attention by the experts.

Kleiner was an exception. In 2003, at the University of Michigan, he and a colleague, John Lott, started running a seminar on Perelman's first paper. This produced a set of notes which they then posted on the web; in those notes, they filled in the details of Perelman's first paper.

What did Perelman himself think of this? According to Kleiner, Perelman was giving a series of lectures at Stony Brook University that same year. Kleiner and Lott approached him and asked if he intended to rewrite his pre-prints and add more detail to make them more readable; his response was that they were written in the best possible way and were therefore complete.

After finishing their work on Perelman's first paper, Kleiner and Lott started writing notes on his second paper, posting those in September 2004. During this time there was steadily increasing publicity within the mathematical community, as well as a lot of perplexity. Kleiner explains, "People didn't understand what was going on. The first question they would ask is, 'Have the Poincaré conjecture, the geometrization conjecture, been proven?' Although the papers were not that long (approximately 30 pages), there was so much detail missing that it wasn't a matter of checking the text; you had to take what Perelman described, interpret it, fill in the details, and then be confident you did it correctly. So they couldn't be verified in the traditional way."

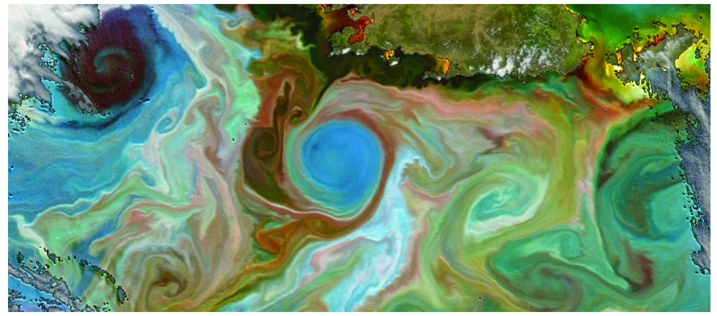
Other teams were analyzing Perelman's papers as well, notably John Morgan and Gang Tian, who ultimately produced a book together. "They thanked us quite generously for having provided the initial set of notes which made it easier for them to produce their own account," Kleiner says.

Then Perelman's story took an even more unusual twist. In part because of Kleiner and Lott's notes and the work of Morgan and Tian, Perelman's work has become fully appreciated. Indeed, he was awarded the Fields Medal in 2006, the highest honor a mathematician can receive – which he then declined. "Which was unheard of!" says Kleiner. "Publicly he said he wanted to remove himself from the mathematical community because he felt there were certain members who had acted in an unethical way and the community had not responded appropriately."

Was Kleiner shocked that Perelman turned down the most prestigious award in mathematics? "He's a very unusual person and his views are far from mainstream," Kleiner explains. "In his two fairly short papers, the number of fundamentally new ideas that he added to the story easily would have made five or six absolutely first rate papers in top journals; even if they hadn't solved this incredibly famous and important problem in mathematics, they would still have been an incredible achievement scientifically."

For Kleiner, elucidating Perelman's papers seemed a natural extension of his early interests. "When I was a graduate student at Berkeley, I was drawn to the Ricci flow because of its mathematical beauty," he explains, "and then after that I didn't really do anything with it. But because of that time in grad school it was easy to pick it up when Perelman's papers appeared. Since then I've gone in that direction with my research, particularly trying to understand the Ricci flow with the perspective that it involves both geometry and analysis. This combination is something the Courant Institute is known for; it's a combination of partial differential equations and geometry, and this is one reason I find it quite exciting to be here – to develop the partial differential equation side of the story. This is a great place to do that." ■

Fifteen Years of CAOS



'Ocean color' data east of Tasmania, December 2004, collected by the MODIS detector on the Aqua satellite.

The Center for Atmosphere Ocean Science (CAOS), an important research initiative within the Courant Institute, which was created under the leadership of Andy Majda in 1994, has grown to seven faculty members. The Center brings mathematical approaches to bear on the changes on our global climate and environment, and studies a vast array of climate issues and phenomena.

This year CAOS hosted its Tenth Annual Workshop on the topic of "Oceanography at the Observational and Modeling Frontier: Submesoscale Dynamics." The workshops provide a unique venue to focus on cutting edge issues in climate science.

The topic of this most recent workshop concerns how the ocean mixes heat, carbon and biological traces in a range of scales that are only now beginning to be modeled and observed. The figure shows 'ocean color' data collected by a NASA satellite (the image is about 20 kilometers across). The colors are not the colors you would see by eye, but represent subtle differences in water color that result from varying distributions of biological and chemical elements in the surface waters. Plainly, the ocean is full of complex fluid dynamical motions (such as vortices and filaments) on these scales. Understanding and predicting ocean mixing on these scales is essential to improving climate models.

The Center is currently housed within the Mathematics Department, but fifteen years after its creation, will become its own department in Fall 2009. ■

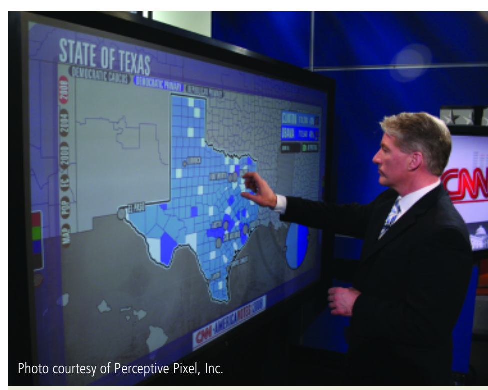


Photo courtesy of Perceptive Pixel, Inc.

A Touch of Magic

Jeff Han, who founded the high-tech start-up Perceptive Pixel and who developed a multi-touch screen while a Research Scientist at Courant, is the man behind CNN John King's "Magic Wall." The seven-and-a-half foot monitor was used by CNN for the 2008 Presidential election coverage, tallying votes, zooming in and out of states, and showing how swing states could change the election result – all with the touch of a few fingers. "It's really helping what news production is for," Han told NYU's Alumni magazine: "to disseminate information, educate the viewer, and break down a complicated thing like these multiple elections."

As Jeremy Bradly of CNN writes, "The inspiration for the multi-touch technology came from a decidedly non-digital event: Han was drinking a glass of water. He noticed the way light was interacting with his fingers as he touched the glass, and an 'Ah ha!' moment was born that put him straight to work."

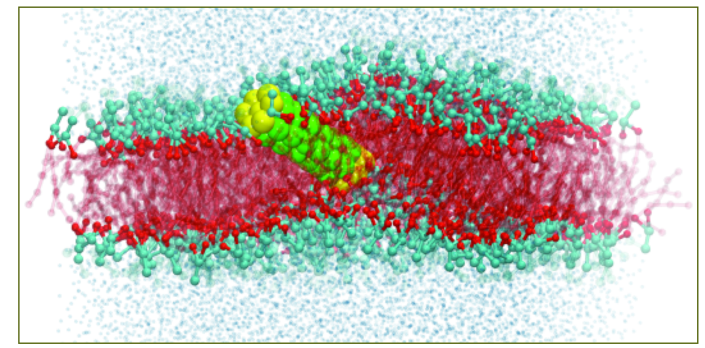
Multi-Touch Screen's are now also being used by Fox News Channel (who dubbed theirs the "Bill-board" for its user, Bill Hemmer), and ABC, and Perceptive Pixel has clients as various as film production companies and the U.S. military. ■

ERIC VANDEN-EIJNDEN:

Understanding Molecules Through Complex Simulation and Statistical Mechanics

by M.L. Ball

"The Courant Institute is an ideal place for someone like me," says Courant Institute Professor Eric Vanden-Eijnden. A citizen of Belgium, Eric earned his B.S., M.S., and Ph.D. in theoretical physics from the Université Libre de Bruxelles. "I came here in 1998 right after finishing my Ph.D., first as a postdoc and then I stayed. Not only do I like the scientific environment here but my family and I really like living in New York."



A snapshot produced by a computational simulation of an insertion of a protein in a lipid bilayer

fairly big molecular systems containing several thousands of atoms for some amount of time," he said. "We can then try to understand how certain molecules evolve in time and how their motion influences their function, for instance. But even with the largest computers, you can't do that by brute force because the range of spatial- and time-scales involved is way too large, and you're simulating a system that is very, very complicated. And so you need to use the statistical mechanics perspective to develop techniques that accelerate the simulations and permit you to interpret the results probabilistically."

Eric sees many innovations on the horizon using this approach. "The growth in computing power and recent discoveries in molecular biology have given new food to mathematics," he explained. "Understanding the structure and functioning of complex macro-molecules provides applied mathematics with enormous challenges but also vast opportunities. To give an example, it is believed that certain proteins – prions, for instance – become lethal only when they misfold into a certain shape. If they are not in this misfolded shape, they are actually pretty benign. It is therefore very important to understand how folding and particularly misfolding happen since it may eventually lead to curing certain diseases." He continued, "Tackling such questions using an applied mathematics perspective is interesting for everyone – for mathematicians, it is a way to extend the realm of their field by confronting new problems; for chemists and biologists, it is a way to systematize their approaches using mathematical and computational tools that have proven very successful in many other settings."

Working in concert with a host of colleagues, Eric focuses in part on developing computational tools at Courant which are then applied globally. "I don't work alone – I have many collaborators, not only mathematicians,

"Mathematics is a universal language for understanding the world around us, and it will be fed by problems in this world for as long as we care to look at them"

One need spend only a few minutes with Professor Vanden-Eijnden to appreciate his love of mathematics, but in school, he was first attracted to astrophysics. "Then I discovered statistical mechanics, a way of looking at a very large system from a probabilistic viewpoint," he said. "In this framework, you don't describe things in detail like you would in classical mechanics. This is not practical when you look at systems such as, say, a gas from a microscopic viewpoint. The number of atoms such a gas contains is just too large and their motion too complicated to focus on each and every atom individually. Rather, you must make global statements about the probability of finding atoms here or there and how this probability influences the bulk properties of the gas. I really fell in love with that topic and its roots in probability theory, and that led me here eventually."

As well as teaching and managing a number of students and postdocs, Eric said that he is mostly working on molecular dynamics with applications to molecular biology and material sciences. He explained, "These are problems in which you try to understand certain chemical reactions or biological processes from first principles, i.e., going all the way down to modeling the motion of the atoms in the molecules involved in these processes. This is important for understanding the basic mechanisms essential to the functioning of your body, such as protein folding. It is also important if you want to understand basic properties of materials, for instance, how they crack under stress, without making constitutive assumptions."

Algorithm development and simulation constitute a large part of Eric's work."With the computer capability we have these days, we can simulate

but also people in chemistry, chemical engineering, and biology departments around the world. These collaborations are essential in enabling us to focus on the problems that are of actual interest in material sciences, chemistry, and molecular biology, and in ensuring that the algorithms developed here are useful in real applications."

The techniques Eric described may have significant applications in the future in the fields of human health, specifically in the context of drug design. "We can't yet say that a new drug is being designed by a pharmaceutical company which was based on first-principle numerical simulation, but it will come. In the same way that numerical simulation helps design airplanes, it will someday help design drugs."

When asked if the world looks to Courant, Eric's answer was immediate. "Most definitely. The Institute is very strong overall, and it is arguably at the top in applied mathematics—not only because of the research being done here but also because of our very successful graduate and postdoc programs. You can go into any mathematics department in the country and find people who have been graduate students or postdocs here and remember it fondly. There is a Courant style of doing applied mathematics that is exported from here."

As for the future of applied mathematics? "I am not worried. Mathematics is a universal language for understanding the world around us, and it will be fed by problems in this world for as long as we care to look at them," Eric mused, laughing. ■

In Memoriam:
Jack Schwartz

"For sheer power and universality Jack's mind had no peer, except for von Neumann."
— Peter Lax

Jack Schwartz, professor at the Courant Institute for forty two years and founder of its Computer Science department, passed away in his Manhattan home on March 2nd. In his lifetime, Professor Schwartz authored more than a dozen books, more than one-hundred papers and technical reports, led a variety of research projects, and advised over fifty Ph.D. students, several of whom became life-long collaborators.

Although he was retired when he passed away, Prof. Schwartz never stopped working. As Computer Science Professor Bud Mishra, to whom Jack was a mentor, remembers, "He never slowed down. He had so many different interests—and he always saw a role for computing and mathematics in them. He was constantly learning."

Two months before his passing, Schwartz decided to learn about optics, so he got a book on Newton's optics and Mishra introduced him to Andrew Hicks, who builds mirrors. Before long, Jack invited Hicks to write a book with him. As Bud tells, "soon Jack was scanning everything 3D in his apartment and making beautiful things. From early Roman History to Chinese music—whatever topic you had, he had an interest."

Not only was Schwartz constantly learning about very diverse topics, he was also teaching them. As Courant Professor Emeritus Peter Lax recalls, "When Jack switched from mathematics to the computer science department, he told that when he first came to the Courant Institute, he looked at our Bulletin and decided to give all the courses listed there." When Lax asked if Schwartz had fulfilled his resolution, he said yes. "Surely," Lax replied, "there must have been some subjects about which you knew very little." "In those cases," answered Jack, "I took out of the library the two or three leading books on the subject and read them."

Schwartz made major contributions to a wide range of areas: spectral theory of linear operators, von Neumann algebras, macroeconomics, the mathematics of quantum field theory, parallel computation, computer time-sharing, high-level programming languages, compiler optimization, transformational programming, computational logic, motion planning in robotics, and multimedia.

In high-level language programming, Schwartz designed a new language called SETL, whose purpose was to allow the succinct expression of algorithms in a form close to their mathematical formulation, and thus easier to understand and reason about. The book Schwartz wrote, *On Programming*, which collected algorithms written in SETL from many fields of computer science, had a significant influence on the design of more recent programming languages, most notably ABC and Python.

His most widely recognized publication as a mathematician was *Linear Operators*, a three-volume work co-authored with Neilson Dunford. Published over three decades ago, it continues to be regarded as the definitive work in the field.

Professor Allan Gottlieb, who came to Courant through the advisement of Schwartz, states that he owes much of his academic success to the efforts, the example set, and the help given by Schwartz, whom everyone called Jack. Almost everyone, that is. For the first few months after he joined Courant, Gottlieb always called him "Professor Schwartz"— "despite his request and the practice of everyone else, from students, to professors, secretaries, staff, and custodians, to call him Jack." Clyde Kruskal, a joint student of Gottlieb and Schwartz's, one day asked Gottlieb why he was "being so foolish." Gottlieb explained as follows:

"Ten years previously, while struggling on my math Ph.D. thesis, I hit a problem in functional analysis that I was unable to solve. I went to the library to seek out the famous text by Dunford and Schwartz, which I had shamefully never read. A trip to the Volume 1 index and then to the page referenced gave me exactly the theorem I needed as well as several corollaries and related results. All this on one page out of 800 in one volume out of three! Such a magnificent edifice could not have been constructed by someone named simply 'Jack.'" Professor Emeritus Louis Nirenberg says of Jack: "he could read mathematics the way I read a novel—for him, reading mathematics was just easy."

Nirenberg recalls a story about a visit Peter Lax made to Schwartz at Stanford. When they met, Jack looked frantic, and said to Peter: "Did you bring something to read? I read the Cornflakes box three times!"

"Everyone was astonished by [Jack's] brilliance," says Nirenberg, of the talk given by Schwartz and Dunford at the Institute. "He knew so much and was so clear."

"More than anything," Mishra recalls of him, "he had a lot of fun. Jack was always having fun."

Schwartz is survived by his third wife, Diana, his daughters, Abby Schwartz of Manhattan and Rachel Fainman of Winnipeg, Manitoba, and his sister, Judith Dunford. ■

New Joann and Stan Benson Fellowship in Mathematics

A generous gift from Joann and Stan Benson has enabled the creation of this new fellowship.

Mr. Benson, M.S. '75, met Mrs. Benson at Warren Weaver Hall during a high school summer course on FORTRAN at NYU. After graduating from Courant, Mr. Benson worked for Pfizer, Inc, a pharmaceutical company, for 19 years in various senior management positions. Mr. Benson then served as Senior Vice President, Sales and Marketing, of Amgen, Inc., a biotechnology company, from 1995 to 2001.

Joann Benson received her M.A. in Statistics in 1976 from Hunter College where she worked under an NSF grant in computer aided instruction. From there she moved on to Pan Am World Airlines. She decided to be a full time homemaker when their third daughter came along. The Bensons have three daughters, Gianna, Bridget, and Linda Fé.

This year, Mr. Benson is completing his M.A. in Art at California State University Northridge. His paintings span a wide variety of subjects and media, from abstract and representational paintings to computer art and oil stains on natural wood. His online gallery can be viewed at http://home.earthlink.net/~stansart/.

By establishing this student fellowship at Courant, the Bensons are pleased to be able to help provide a Courant student with the same type of opportunity that led to their success. ■

Sudokill
a strategic variation of **Sudoku**

by **Dennis Shasha**, *Professor of Computer Science*

I suspect that among the readers of this newsletter, few are unfamiliar with Sudoku. The same cannot be said about Sudokill, a game invented for a graduate class I teach in heuristic problem solving. Sukokill is a two person game which pits player against player in trying to force the other player to violate the Sudoku rules.

Here's a quick refresher on Sudoku. The goal is to fill a 9 by 9 grid with digits between 1 and 9. Each digit should appear exactly once in each row, once in each column, and once in each non-overlapping three by three box starting from the upper left corner.

In the following example, we use 0 to represent a blank.

```
0 0 0|0 0 0|0 0 7
7 0 4|0 0 0|8 9 3
0 0 6|8 0 2|0 0 0
-----+-----+-----
0 0 7|5 2 8|6 0 0
0 8 0|0 0 6|7 0 1
9 0 3|4 0 0|0 8 0
-----+-----+-----
0 0 0|7 0 4|9 0 0
6 0 0|0 9 0|0 0 0
4 5 9|0 0 0|1 0 8
```

Consider the lower left box:

```
0 0 0|     |
7 0 4|     |
0 0 6|     |
-----+-----+-----
0 0 7|     |
0 8 0|     |
9 0 3|     |
-----+-----+-----
0 0 0|7 0 4|9 0 0
6 0 0|0 9 0|0 0 0
4 5 9|0 0 0|1 0 8
```

We know that of the five zeroes present in the lower left box, one must be 7 and one must be 8. Because there is a 7 in the third column and the seventh (from the top) row, the only legal place for a 7 is to the right of the 6, yielding:

```
0 0 0|     |
7 0 4|     |
0 0 6|     |
-----+-----+-----
0 0 7|     |
0 8 0|     |
9 0 3|     |
-----+-----+-----
0 0 0|7 0 4|9 0 0
6 7 0|0 9 0|0 0 0
4 5 9|0 0 0|1 0 8
```

By contrast, the following would be illegal:

```
0 0 0|     |
7 0 4|     |
0 0 6|     |
-----+-----+-----
0 0 7|     |
0 8 0|     |
9 0 3|     |
-----+-----+-----
0 7 0|7 0 4|9 0 0
6 0 0|0 9 0|0 0 0
4 5 9|0 0 0|1 0 8
```

because then there would be two 7s in the same row.

In Sudokill, players alternate moves where a move consists of replacing a blank by a number. The first player is called the row player, and the second is the column player. Initially, the row player can make any legal Sudoku move. Subsequently, the column player must move in the same column as the last move of the row player and the row player must move in the same row as the last move of the column player. If a player makes an illegal Sudoku move, then that player loses.

If we represent blanks as 0s or letters, if the row player moves where there is an x:

```
0 0 6|0 0 0|0 0 0
8 4 0|3 x 2|0 0 0
3 2 0|0 0 5|0 7 4
-----+-----+-----
0 6 0|0 9 0|8 0 0
0 0 0|6 2 4|0 0 0
0 0 2|0 3 0|0 6 0
-----+-----+-----
2 1 0|9 0 0|0 8 7
0 0 0|4 0 3|0 2 5
0 0 0|0 0 0|1 0 0
```

then the column player must replace a blank in the same column (marked with ys):

```
0 0 6|0 y 0|0 0 0
8 4 0|3 x 2|0 0 0
3 2 0|0 y 5|0 7 4
-----+-----+-----
0 6 0|0 9 0|8 0 0
0 0 0|6 2 4|0 0 0
0 0 2|0 3 0|0 6 0
-----+-----+-----
2 1 0|9 y 0|0 8 7
0 0 0|4 y 3|0 2 5
0 0 0|0 y 0|1 0 0
```

Suppose the column player chooses the one marked by an upper case Y:

```
0 0 6|0 y 0|0 0 0
8 4 0|3 x 2|0 0 0
3 2 0|0 y 5|0 7 4
-----+-----+-----
0 6 0|0 9 0|8 0 0
0 0 0|6 2 4|0 0 0
0 0 2|0 3 0|0 6 0
-----+-----+-----
2 1 0|9 y 0|0 8 7
0 0 0|4 Y 3|0 2 5
0 0 0|0 y 0|1 0 0
```

Now the row player must move in one of the positions marked with a z:

```
0 0 6|0 y 0|0 0 0
8 4 0|3 x 2|0 0 0
3 2 0|0 y 5|0 7 4
-----+-----+-----
0 6 0|0 9 0|8 0 0
0 0 0|6 2 4|0 0 0
0 0 2|0 3 0|0 6 0
-----+-----+-----
2 1 0|9 y 0|0 8 7
z z z|4 Y 3|z 2 5
0 0 0|0 y 0|1 0 0
```

Toward the end of the game, the following rules prove important: if there are no blanks in the column where the row player last moved, then the column player may move anywhere. Likewise, if there are no blanks in the row where the column player last moved, the row player may move anywhere.

Warm-up: Suppose it is the row player's move in the following situation (where letters represent blanks):

```
5 7 6|1 4 9|2 3 8
8 4 9|3 7 2|5 1 6
3 2 1|8 6 5|9 7 4
-----+-----+-----
4 6 3|7 9 1|8 5 2
1 5 8|6 2 4|7 9 3
7 9 2|5 3 8|4 6 1
-----+-----+-----
2 1 4|9 5 6|3 8 7
9 8 7|4 1 3|6 A 5
6 3 5|B 8 7|1 C 9
```

How can the row player force a win (i.e., force the column player to make an illegal move)?

Solution: Suppose the row player puts a 2 on the bottom row (replacing the C), yielding:

```
5 7 6|1 4 9|2 3 8
8 4 9|3 7 2|5 1 6
3 2 1|8 6 5|9 7 4
-----+-----+-----
4 6 3|7 9 1|8 5 2
1 5 8|6 2 4|7 9 3
7 9 2|5 3 8|4 6 1
-----+-----+-----
2 1 4|9 5 6|3 8 7
9 8 7|4 1 3|6 A 5
6 3 5|B 8 7|1 2 9
```

Then the column player has to move where the A is. The Sudoku rules would suggest replacing the A by a 4 to satisfy the constraints within the lower right hand box. But that would violate the row constraint, because there is already a 4 in that row.

End of Warm-Up: Now it's your turn, but this time we'll favor the column player.

1. Can the column player force a win in two moves given the following board? (Here the column player can begin by moving anywhere.)

```
8 1 5|3 4 9|2 6 7
7 A 4|B 5 1|8 9 3
3 9 6|8 7 2|4 1 5
-----+-----+-----
1 4 7|5 2 8|6 3 9
C 8 2|9 3 6|D E 1
9 6 3|F 1 7|G H I
-----+-----+-----
2 3 1|J 8 K|9 5 6
6 7 8|1 9 5|3 2 4
L 5 9|2 M 3|1 7 N
```

2. Here's a harder one. Can the column player force a win in three moves given the following? (Again the column player can begin by moving anywhere.)

```
7 A 5|8 1 3|2 9 B
C D 1|4 7 6|5 E F
3 4 G|2 5 9|H 1 7
-----+-----+-----
9 1 4|5 8 7|3 2 6
I 5 7|3 6 2|J 4 9
6 2 3|9 4 1|7 K L
-----+-----+-----
1 3 2|6 9 8|4 7 M
N 8 O|P 2 5|9 3 1
Q 7 9|1 3 R|8 6 2
```

Here's an invitation. If you can produce a four move forced win on a board initially having more blanks than assignments, please send it to me at shasha@cims.nyu.edu. Also, please play Sudokill at Yu Yiwen's website: http://homepages.nyu.edu/~yy497/projects/showcase/SudokillWebGame

For the solution email:
courant.alumni@nyu.edu

Photos: Annemarie Poyo Furlong

Warren Weaver Hall

In 1965 Warren Weaver Hall was given a Bard Award for excellence in New York Architecture by the City Club of New York. While the building's exterior, designed by Warner, Burns, Toan & Lunde, remains the same as it was nearly forty five years ago, its interior has recently undergone substantial renovation. Over the past two years, floors two through five have seen significant changes, including five new classrooms, new conference rooms, and a new computer lab. The new second floor computer lab consolidates the two previous fifth floor labs into one space. The lab comprises two rooms, separated by a pane of glass, and has a total of 33 workstations. Some other special features included in the renovations are raised classroom seating on the second floor, to allow for a better view of the board, and a "Smart Board" – an interactive white board. Renovations on the remaining floors (six through nine) are expected to be completed by the end of 2010. ■

Alumni Spotlight

Sashi Reddi, M.S. in Computer Science '90, Courant Institute; Ph.D. '93, Wharton School of Business, The University of Pennsylvania

Sashi Reddi is founder and chairman of AppLabs, the world's largest independent testing, quality management and certification solutions company. He is also the founder and chairman of FXLabs, a leading developer of high quality game products for PC's and Videogame consoles. A serial entrepreneur, Sashi had previously started two other companies: EZPower Systems and iCoop.

"AppLabs was started when I realized that with an increasing number of organizations automating their business processes, there was a growing need for the companies to test the efficiency of their software and IT systems," says Sashi. "And I found that they prefer to engage the services of an independent testing and quality management company for an unbiased appraisal." AppLabs is backed by Sequoia Capital, which invested around $23m in AppLabs.

FXLabs is the leading end-to-end game development company in India, and has its head office in Hyderabad, India. It takes advantage of multi-shore development, and uses its own IP, to develop games with Indian content both for the Indian market as well as a wider international market.

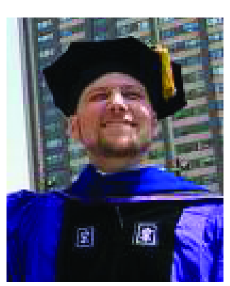
Its recent game based on a Bollywood movie has become the biggest selling videogame ever in India.

"When I joined Courant for a Master's in 1987, that was my first time in the US. A lot of my views on what is possible have been shaped by my initial experiences interacting with some great minds at Courant inter-mixed with life in the East Village. It was a strange but potent combination of experiences that got me thinking out of the box on what I could do with my life," says Sashi.

Sashi received his BTech (Bachelor of Science) degree in Computer Science from the Indian Institute of Technology in Delhi, and after earning his Master's in Computer Science at Courant, he earned his Ph.D. from The Wharton School of Business, The University of Pennsylvania. ■

In Memoriam: Thomas Bringley

(1981-2008)



Thomas Tyler Bringley, beloved student and friend, passed away on June 22, 2008 after a long battle with cancer. Tom "was a superb student and colleague," says Courant Director Leslie Greengard, "who continued to excel in his coursework and research despite the most adverse of circumstances."

Tom arrived at the Institute in the Fall of 2003, after undergraduate work at Duke in math and physics, and completed his Ph.D. here in May 2008. According to his advisor, Charlie Peskin, Tom's work at Courant involved two research projects: "one of these solved a 50-year old mystery on the mechanism of valveless pumping, and the other introduced and validated a new immersed boundary method for Stokes flow on unbounded domains. The latter won a student paper prize from SIAM. Tom's work was characterized by physical and analytical insight, technical brilliance, and tremendous originality."

A conference was held in Tom's memory on March 28th, 2009, with eight speakers discussing problems related to Tom's mathematical interests, and including a talk by Charlie Peskin on Tom's doctoral thesis, "Analysis of the Immersed Boundary Method for Stokes Flow."

Since his passing, Tom's wife, Krista, his family, and his colleagues and friends have raised funds to create the Thomas Tyler Bringley Memorial Scholarship, which will support the work of a Ph.D. student studying applied mathematics at the interface of many disciplines, guiding applications in medicine and biology. The Scholarship has over 150 donors to date, from individuals from Rochester to California.

Tom was an exemplary student and a very kind individual, and he is missed greatly by his family, and his many friends at the Courant Institute. ■

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Your donations to the Courant Annual Fund are more important than ever. This unrestricted income is supporting students and their conference travel, and is enhancing the activities of our student clubs including the cSplash and WinC outreach programs. In April, cSplash hosted 250 local high-school students to the Institute for an introductory math day and in March, the Women in Computing student group's outreach day was attended by 230 New York area high school girls. The Annual Fund is also providing matching funds to secure grants from other sources, is allowing Courant to invite distinguished speakers for both technical and public lectures, is assisting with furnishing the newly renovated floors in Warren Weaver Hall, including providing furniture for Ph.D. student offices, and is creating improved public spaces in both Warren Weaver Hall and the Broadway building.

In September 2009, we will have our second Director's Circle dinner in recognition of donors at the $1,000 and above level, with a special talk by Raghu Varadhan, Abel Prize Winner. We invite you to join this group with a $1,000 or higher donation to the Courant Annual Fund.

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Also, University Development and Alumni Relations provides VioletNet, (violetnet.nyu.edu) a searchable directory of all NYU Alumni and an "interactive community designed especially for NYU alumni."

Please keep us updated on your address and phone number. Email **Courant.Alumni@nyu.edu**.

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The Courant Institute invites all Alumni to keep colleagues and friends up-to-date on life events. All items submitted (such as career achievements and family milestones) will be considered for publication in the Newsletter or online. Please send the details to **alumni.news@cims.nyu.edu**.

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