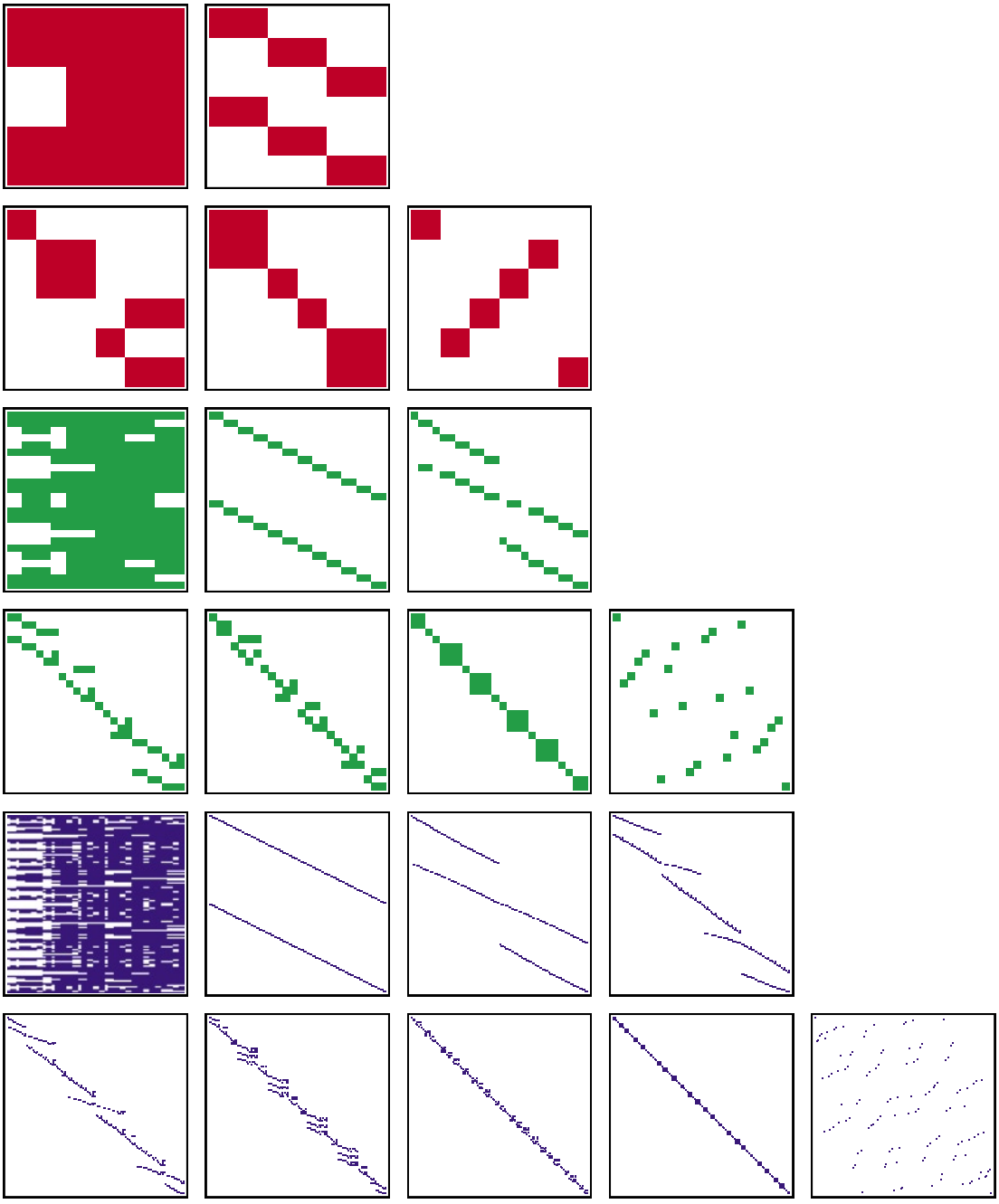
MUDDmath

Harvey Mudd College

Volume 5, Issue 1 ■ 2006



Greetings and Salutations

Welcome to the next edition of **Mudd**math! In this issue, Professors Jacobsen and Yong give you a detailed description of all the exciting work going on in our department over the last two academic years.

The 2005–06 academic year was a particularly memorable one. In November 2005, we learned that the American Mathematical Society (AMS) was honoring our department with the first-ever Award for Exemplary Program or Achievement in a Mathematics Department. The AMS created this award to "recognize a department which has distinguished itself by undertaking an unusual or particularly effective program of value to the mathematics community, internally or in relation to the rest of society." As part of the award, the department was profiled in the April 2006 issue of the *AMS Notices*, and we have reprinted that article in this issue so that you can read their ideas about why our program is effective.

2005 began with a big splash as seven HMC undergraduates presented papers and posters at the annual Joint Meeting of the AMS and the Mathematical Association of America (MAA) in Atlanta. The four poster presenters received prizes for outstanding presentations. Later in the year, senior Julijana Gjorgieva was distinguished for a second consecutive year at the Society for Advancement of Chicanos and Native Americans in Science Conference, with the award for best undergraduate paper in mathematics. Right after the Atlanta meeting, while attending a subsequent mathematics meeting in Chile, I was pleasantly surprised by an e-mail message that further documents the impressive quality of our students' presentations. The e-mail message states: "I would very much like to visit Harvey Mudd College to promote our graduate program among your students and answer questions they may have. The best set up for this would be if I could give a talk in your department. I am happy to do this at my department's expense." Subsequently the message sender visited our department, as did quite a few other mathematicians from top graduate departments. The tradition of Mudders presenting at the Joint Meetings continued in 2006 with eight Mudders presenting at the 2006 meeting in San Antonio. Francis Su was also invited to deliver a plenary address at the meeting.

In 2005, we also welcomed two more mathematicians to HMC: Daniel Goroff from the Department of Mathematics at Harvard University became our new dean of the faculty, and Susan Martonosi from the Operations Research Center at MIT became our newest assistant professor. Susan's position replaces Hank Krieger's, who retired in 2005 after 37 years of dedicated service to the college. By the end of the year, we learned that 2006 would welcome two more mathematicians to HMC. Maria Klawe, Dean of Applied Sciences and Engineering at Princeton, will become HMC's fifth president, and her husband Nicholas Pippenger from the Department of Computer Science at Princeton will join the department as a professor of mathematics. We are thrilled with the new additions to the department and college.

The good news goes on. In 2006 Lesley Ward was awarded the Henry L. Alder Award for Distinguished Teaching by a Beginning Faculty Member by the MAA, and Art Benjamin was awarded the MAA's Beckenbach Book Prize for his book *Proofs that Really Count: The Art of Combinatorial Proof*, co-authored with Jenny Quinn (executive director of the Association for Women in Mathematics). As I was getting ready to write this note, the National Academy of Science (NAS) announced that their first-ever Proceedings of the NAS Paper of the Year Prize has been awarded to Karl Mahlburg '01 for his article, "Partition congruences and the Andrews-Garvan-Dyson crank."

Indeed, it is a wonderful time for mathematics at Harvey Mudd College, and I hope that you enjoy reading about our news and, more importantly, will share with us any news about your lives as well. The pessimist in me makes me worry that we may have reached a high point from which we can only go down. To subside this, we have put together a committee that includes active and emeritus faculty to deal with the question: "And now what?" With your support, we will climb to new heights.

Sincerely,

Alfonso Castro
Kenneth and Diana Jonsson Professor of Mathematics and Chair

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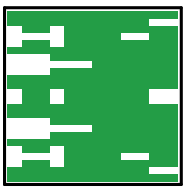


The figures on the cover are the work of Eric Malm '05 and Professor Michael Orrison. They depict factorizations of discrete Fourier transforms for the symmetric group S_N into products of sparse matrices. Such factorizations increase the computational efficiency of the transform significantly, turning it from a process requiring $O(N!^2)$ operations into one requiring only $O(N^2N!)$ operations. These matrix factorizations generalize the well-known Fast Fourier Transform, which has been a crucial component of signal processing algorithms since its introduction in 1965. For more information, see the Applied Representation Theory Group's web-site at http://www.math.hmc.edu/~orrison/art/.

Muddmath is published by the Harvey Mudd College Department of Mathematics, 301 Platt Boulevard, Claremont, CA 91711, http://www.math.hmc.edu. Jon Jacobsen and Darryl Yong, Editors.
Additional assistance from the HMC Office of College Relations. Photography by Francis Su, Jon Jacobsen and Kevin Mapp.
This, past and future issues of **Mudd**math are available on the web at http://www.math.hmc.edu/muddmath/.
Inquiries, suggestions, comments and alumni updates are welcome and can be emailed to muddmath@math.hmc.edu.

Harvey Mudd College is a coeducational liberal arts college that seeks to educate engineers, scientists and mathematicians, well versed in all of these areas and in the humanities and the social sciences, so that they may assume leadership in their fields with a clear understanding of the impact of their work on society.

Harvey Mudd College Mathematics Department Garners AMS Award

The following article by Allyn Jackson first appeared in the April 2006 issue of the Notices of the American Mathematical Society*, and is reprinted here with permission.*

Ten years ago the mathematics department at Harvey Mudd College was a very good department known for excellent teaching and for innovations like its "clinic" in which student teams work on mathematics problems from industry. The department was doing well, and likely there would have been no complaints had it remained as it was. Instead, the department has over the past decade brought itself up to a new level to become one of the best places in the nation to be an undergraduate mathematics major. The quantitative measures of the department's success went through the roof, with the number of majors tripling and more than half of them going on to graduate school. But what really changed is how the department unified itself around its core mission of promoting teaching and scholarship in ways that inspire faculty and students alike to do their best work. For its outstanding performance, the Harvey Mudd College mathematics department this year received the first-ever AMS Award for an Exemplary Program or Achievement in a Mathematics Department.

How did the department get to where it is today? One important factor is that it built upon its strengths, one of which is the Harvey Mudd College Mathematics Clinic. Professor emeritus Robert Borrelli was deeply involved with the clinic from its inception in the 1970s, and other faculty—Stavros Busenberg, Courtney Coleman, and Henry Krieger—served as directors of the clinic up to the 1990s. The clinic teams up senior mathematics majors to work on mathematical problems supplied by industry. These are real-life problems, messy and ill posed, and a crucial factor in making the program work was the ingenuity of the Harvey Mudd College faculty in figuring out how to distill the problems down to workable projects for the student teams. During the 1970s and 1980s the faculty introduced other innovations as well; for example, Borrelli and Coleman encouraged their students to experiment with software for solving partial differential equations at a time when not much of this kind of software was around. This experimentation evolved into the ODEToolkit, now available on the Web. Borrelli and Coleman also founded an interdisciplinary student research journal called *Interface*.

In the mid-1990s the department, facing a big wave of retirements, seized the opportunity to reinvent itself. A key step was hiring Michael Moody, a mathematical biologist from Washington State University, to take over as department chair. "He was a wonderful leader, very charismatic, with lots of ideas," noted Lesley Ward, who came to Harvey Mudd College in 1997. "He would see what should be done in the future and then lay out the steps to get there." Moody set for the department what he called an "animating goal": To be recognized as one of the very best undergraduate programs in the country.

During Moody's six years as chair, from 1996 until 2002, the department hired eight new professors; the total number of faculty is twelve. He and Arthur Benjamin, who had come to Harvey Mudd College in 1989, worked as a team to do much of the hiring. Moody recalled that he and Benjamin resonated on what they wanted: "We wanted people who would mesmerize and inspire students in the classroom *and* have a passion for their mathematical work." In addition, the department was lucky in the timing of its hiring. Current chair Alfonso Castro, who came to Harvey Mudd College three years ago, noted that because the 1990s were tough years for job seekers in mathematics, the department was able to hire junior people who under different circumstances would likely have gone to top research universities. "These young faculty not only bought into the mission of quality teaching at the undergraduate level, they also established a first-rate presence in the research community," he said. Some of the candidates sensed the department's newfound dynamism and were attracted by the prospect of contributing to the building of a new department. "That was exciting to me," noted Francis Su, who came to Harvey Mudd College in 1996.

Young, newly hired faculty were given big responsibilities early on. Soon after Ward came to Harvey Mudd College, she and Su, together with senior faculty member Henry Krieger, took on the task of restructuring the department's core curriculum. This two-year collection of courses is taken by all Harvey Mudd College students. After consulting with other departments about what their majors needed to get out of the core mathematics curriculum, Krieger, Su, and Ward reconfigured the four, semester-long courses into eight courses that run half a semester each. They also added to the core a new course in statistics and probability and introduced a strand in discrete dynamical systems. "This bought us huge credibility inside the institution," Moody noted, because the other departments felt that their concerns were heard and taken into account. He took flak from some senior faculty who considered the changes too radical, but he was not perturbed. "I grew up in a system where assistant professors were seen and not heard to a large extent," he noted. "But they have creativity and energy, and if you leaven that with an experienced person who has a light hand on the tiller, they'll do great things. Plus they'll be invested in it."

Also around this time the department revamped the mathematics major. Over the years the major had morphed into a system with several different tracks, and there would sometimes be just one or two students per track, leaving them feeling somewhat isolated. The department now has a single, unified major centered on a core set of six advanced courses. Students take electives to customize

their own programs in consultation with faculty advisors. In addition, the department launched two new majors: the joint major in computer science and mathematics that started in 1998 and a major in mathematical biology that started in 2001.

Every senior major in the department must take part in a "senior research experience", which can mean either participating in the mathematics clinic or writing a senior thesis. The strong tradition built up over thirty years of running the clinic served the department well when directorship of the clinic passed in 1999 from Borrelli to then-newly hired faculty member Michael Raugh. (Raugh also created and serves as the director for a version of the clinic at the Institute for Pure and Applied Mathematics at the University of California, Los Angeles.) The range of topics covered in the Harvey Mudd College Mathematics Clinic is enormous; in recent projects, students have worked on such topics as gene expression data, global positioning system algorithms, soliton-like water waves, and cryptography.

The department set about revitalizing its senior thesis by raising standards and by introducing additional structure, such as having students participate in a weekly seminar in which they give talks to each other about their work as it progresses. Small changes like preparing hardbound copies of theses and storing them on shelves where students can browse through them help to convey the message that the department believes that writing a senior thesis is a serious and substantial undertaking. At the end of the year, all graduating seniors must participate in "Presentation Days," a three-day, collegewide miniconference in which students from all departments present talks about their work. "The fact that we as a college decided it's more important to have three days of presentations than three more days of lectures says a lot about how the college values undergraduate research," commented Ward.

But is it really possible to involve undergraduates in mathematics research? Absolutely, said Su. "I believe undergraduates at any level can do research," he said. "There are many kinds of research experiences. In terms of serving a student, what is valuable for the student is learning to inhabit the research process." The goal is to give the students an experience in mathematical discovery that allows them to understand what research is like. Su noted that even in a deep field where there are not many easy problems lying around—say, differential geometry—there are nevertheless problems that undergraduates can sink their teeth into. For example, his colleague Weiqing Gu has come up with problems in *M*-theory and string theory that boil down to specific systems of partial differential equations. Without possessing extensive background, an undergraduate can work on solving such systems and make progress on understanding them analytically and geometrically. The proof that the department's approach works is in the publications: Since 2002 at least twenty papers have been published, many of which were based on senior theses and written jointly by faculty and students, and many students have published papers on their own. There are other proofs as well. Harvey Mudd

Jacobsen and Su demonstrate the fluid dynamics of a vortex cannon.

College mathematics major Joshua Greene received the 2002 AMS-MAA-SIAM Morgan Prize for outstanding research by an undergraduate, and another Harvey Mudd College student, Aaron Archer, was a runner-up for this distinction in 1998.

Of course, for the students to have a meaningful research experience, the faculty themselves have to be engaged in research. And at Harvey Mudd College, they are. The department's publication output is impressive, and several faculty are supported by research grants from the National Science Foundation (NSF). The Keck Foundation provided a three-year grant for the Center for Quantitative Life Sciences, which is codirected by mathematics faculty member Lisette de Pillis and a biology faculty member. The center has developed new courses in mathematical biology, hosted research visitors, and funded two dozen multidisciplinary summer research projects. The Harvey Mudd College mathematics faculty has also been represented in major research conferences: Gu was an invited speaker at the International Congress of Mathematicians in Beijing in 2002, and four other faculty—Ward, Su, de Pillis, and Andrew Bernoff—have been course lecturers at the Park City Institute for Advanced Study summer mathematics conferences. In 1999 the department began organizing its own annual, one-day regional research conference. With topics ranging over analysis, algebra, geometry, mathematical biology, and scientific computing, the conferences typically attract fifty to seventy-five participants. Although this is a bona fide research conference, with experts in the field presenting their latest work, Harvey Mudd College students are encouraged to attend just to soak in the atmosphere. "We always have significant student attendance at the conferences," Moody remarked.

Hand in hand with the emphasis on research and scholarship is the department's strong commitment to excellence in teaching. As Ward put it, at Harvey Mudd College "it's okay to spend a lot of time on making your classes great." As at other places, the college is trying to come to grips with how to document good teaching. Student evaluations are used; also, when an individual comes up for promotion or reappointment, he or she must get

other faculty members to write letters of recommendation focused on teaching. But what really seems to make the biggest difference in the department's teaching is a highly developed sense of collegiality and collective responsibility. "We are really generous and free in sharing teaching ideas," Su noted. He recalled that when he was teaching a certain course for the first time, his colleague Art Benjamin lent his lecture notes to Su. It has become a tradition to hand down one's lecture notes. Su has developed a large collection of what he calls "Fun Facts", interesting tidbits about a wide variety of mathematical topics that can be presented in about five minutes at the beginning of a lecture to awaken students' interest and expand their ideas of what mathematics is. Su started sharing the "Fun Facts" over the Web, and now other professors are using them. On a daily basis the faculty discuss with each other many teaching issues, large and small. "If we go to lunch, we are as likely to be discussing teaching as research," Ward remarked. The college has no teaching awards, but Harvey Mudd College mathematicians have received such awards at the national level: In 2000, Benjamin received the Haimo Award of the Mathematical Association of America, and in 2004 Su received the MAA's Alder Award.

The department's efforts to renew itself have made a big difference in its ability to attract students into mathematics. "The students picked up a different feel" from the mathematics department, Moody noted. "They could tell we really cared about them." The number of mathematics majors increased from a low of ten in 1993 to about thirty per year in recent years. The class of 2006 has forty-one majors, nearly one quarter of Harvey Mudd College seniors (this number includes computer science/mathematics and mathematical biology majors). The number of women has also increased, and women now account for about one third of all mathematics majors, the same proportion in which women are represented in the Harvey Mudd College student body. (With the hiring in fall 2005 of Susan Martonosi, the proportion of women in the mathematics department faculty is also one third.) Among students who finished the mathematics major between 2002 and 2005, about 60 percent went on to graduate school, and many were accepted in the top mathematics graduate programs in the country. In the past five years, nineteen Harvey Mudd College mathematics majors were awarded the prestigious NSF Graduate Research Fellowships, and another sixteen were named honorable mentions. Majors who do not choose graduate school are heavily recruited by business, industry, and government.

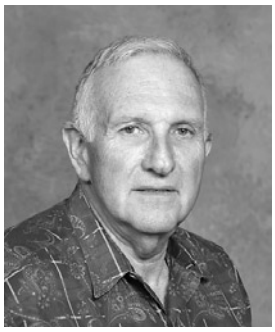
Not only has the department attracted more mathematics majors, it has also attracted more nonmajors to take part in its programs. For example, sixty to seventy students—about 10 percent of the Harvey Mudd College student body—take part in the weekly Putnam Seminar, in which the students work on practice problems for the Putnam Competition. The seminar is led by Bernoff and Su, who have put the emphasis on having fun solving problems rather than on honing an elite team. In the process, the department *does* manage to hone an elite team: Harvey Mudd College has placed in the top ten nationwide in the Putnam Team Competition in four of the past five years and is the only undergraduate college to have made it into the top five in the last thirty years. High participation by non mathematics majors also occurs in the Mathematical Contest in Modeling and the Interdisciplinary Contest in Modeling (both of which are sponsored by the Consortium for Mathematics and its Applications). Harvey Mudd College has done very well in both competitions, and the winning teams have often combined mathematics majors and nonmajors alike.

Even with all the energy and attention the department puts into its own programs, it nevertheless manages to find ways to reach out beyond the campus. In 2000 mathematics faculty member Darryl Yong, together with three Harvey Mudd College faculty from other departments, started an outreach program in Pomona High School, which is in a low-income neighborhood. This program brings Harvey Mudd College students into the school's classrooms, which are populated mostly by Latino students, to lead activities designed to inspire interest in mathematics, science, and engineering. In 2004 mathematics faculty members Michael Orrison and Jon Jacobsen traveled to Jamaica to lead a workshop designed to enrich the mathematical background of Jamaican teachers. They plan to offer the workshop again in 2006.

Harvey Mudd College recently hired mathematicians in its top two administrative posts: Daniel Goroff came from Harvard University to become vice president and dean of the faculty in July 2005, and Maria Klawe will come from Princeton University to take up the post of president in July 2006. And a couple of years back, the college lost a faculty member who went on to an administrative post—namely, Michael Moody, who is now the dean of faculty at Franklin W. Olin College of Engineering, an innovative engineering school that opened its doors in 2002. Moody was thrilled when the department received the AMS Award for Exemplary Achievement and also felt a pang of homesickness. "I'm so proud of the department," he said. "I can't imagine a more deserving group of people—I am completely biased of course!—but they really are incredibly dedicated to mathematics and to the community they have created."

Where does the department go from here? How does it sustain its success? Moody pointed to the need to continue to develop programs that bring faculty together as teams so that they set aside differences and work toward a common good. Su said he has seen exactly this happening organically in the department: One faculty member gets an idea to try something new, and he or she convinces colleagues to come on board. If too many ideas proliferate, the department will have to prioritize, but for now Su is happy to let things develop in this organic way. "But whatever we do, our mission is to engage undergraduates in research and discovery," Su said. "That will always be central."

Hank Krieger Retires

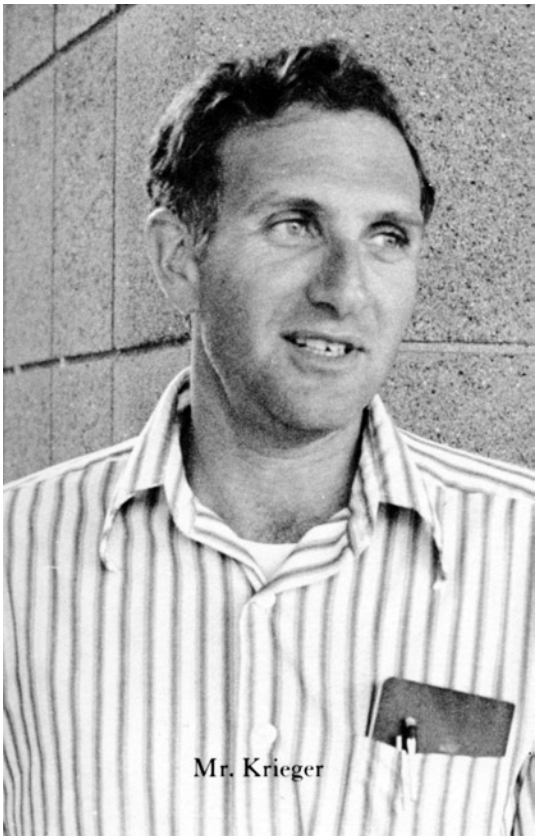


After 37 years of service to Harvey Mudd College, Hank Krieger retired from teaching mathematics in May 2005. Hank's contributions to the college and department are numerous and continue to impact us positively. In addition to his teaching and mentoring duties, Hank chaired the mathematics department from 1990 to 1995 and served as the college's director of Freshmen Division and chair of faculty.

Those of you who know Hank well also know that his name is practically synonymous with CMS Stags Tennis. Coach Krieger was inducted into the CMS Athletic Hall of Fame in 2004, recognizing a 22-season coaching tenure in which the Stags won over 400 matches. Twice named the NCAA Division III Coach of the Year (in 1985 and 1993), Hank was at the helm for the Stags only national championship (in 1981) and has coached 24 All-Americans.

Hank is still actively working on several academic projects, as well as serving on a handful of community-based committees and boards. He and his wife, Rita, will continue to live in Claremont. They have two grown children and four grandchildren.

Our sentiments toward Hank are nicely summed up in the following speech of Art Benjamin's that was read at Hank's retirement reception by Lisette de Pillis.



Reproduced from 1976 HMC yearbook.

Reproduced from 1973 HMC yearbook.

"It's hard to imagine life at HMC without Hank Krieger. Indeed, without Hank, our department and college would be a very different place today.

"As chair of the math department, Hank hired Dave Bosley, Lisette de Pillis, Ran Libeskind-Hadas, Mike Moody, and chaired the search committee that hired Francis and Weiqing. And not only did Hank have a big impact on *who* we are, just as importantly he affected *how* we are with each other. As chair of the department and chair of the faculty, Hank exuded calm, rational thinking, and promoted civil dialogue for which we shall forever benefit.

"Hank was also the source of a great many problems.

(PAUSE)

"I mean, a source of math problems, of course! Without a doubt, Hank has been the department's most versatile teacher and problem solver. Hank is the only person in our department who has taught every course in the core and most of our upper division and graduate-level courses. I struggle to think of any course that we offer that Hank has not taught and which has not benefited from Hank's influence. His teaching has been appreciated by more than 35 years' worth of students, and will indirectly enhance the learning of future students for years to come.

"I am personally grateful for all that Hank has done for me at every stage of my career. He collaborated with me on research problems, co-taught classes with me supported my tenure and promotion. He gave me uncountably many suggestions, ideas, and most of all, a model example of how to be an effective chair. He even loaned me his house and car while he was on sabbatical one semester. And I know that Hank's generosity has extended to all of us, and that he will continue to play a major part in our lives as the years go on.

"As I said, it's hard to imagine life at HMC without you, Hank, so please don't be a stranger around these parts. Here's to many more wonderful years together. Thank you for so much."

HMC Students Present at National AMS-MAA Meeting

Each January, the American Mathematical Society (AMS) and the Mathematical Association of America (MAA), the two largest professional mathematical societies in the United States, hold a joint meeting. The meeting offers a myriad of opportunities for our faculty to speak on their latest research and/or curricular efforts. The meeting is also famous for its central role in the mathematics job search process. But, for Mudders it is increasingly known as a place where they might present their research. The meeting offers students several speaking venues, including advanced research-focused "Special Sessions," Special Sessions focused on Undergraduate Research, and an Undergraduate Poster Session. Speaker slots are competitive and our students must earn the opportunity to speak by submitting their abstract through the AMS-MAA web-site. Students may present on research that occurred in their senior theses with HMC professors, or in summer research here at HMC or at other summer REUs.

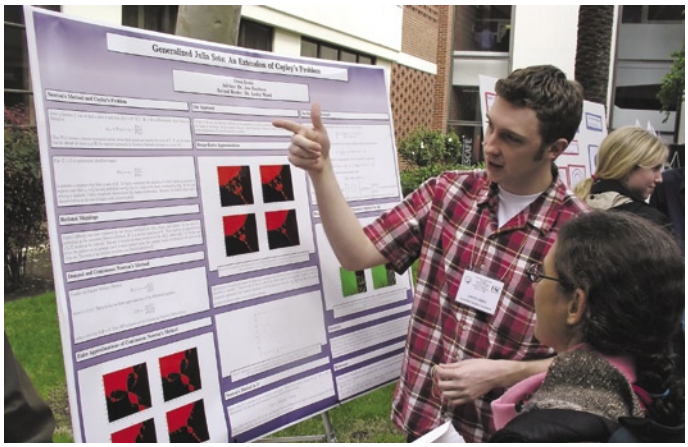
In 2005, seven students presented their research at the Joint Meetings held January 5–8 in Atlanta. Brian Tagiku '05, Zajj Daugherty '05, Akemi Kashiwada '05, Gwen Spencer '05 and Eric Malm '05 were all selected to speak in a Special Session on Undergraduate Research. They were five of about 25 students who spoke in that session. Also, Carl Yerger '05 spoke in a Combinatorics session, and Julijana Gjorgieva '06 and Ivan Ventura '07 presented posters on their research at the Undergraduate Poster session, as did Spencer and Kashiwada. All four HMC students who presented posters received a cash prize of $100 for their outstanding presentations.

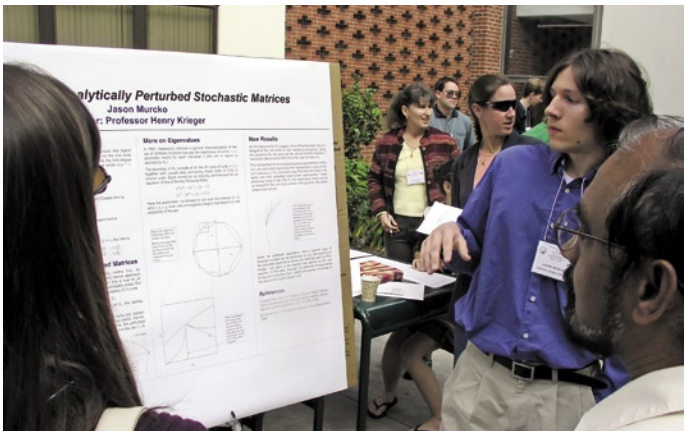
In 2006, the tradition continued with eight Mudders presenting at the meeting, which occurred in San Antonio. Mathematics majors Robin Baur '06, Debbie Berg '06, Tristan Brand '06, Alex Eustis '06, Julijana Gjorgjieva '06, Tyler Seacrest '06, Marie Jameson '07 and Greg Minton '08 made presentations. Debbie Berg, Alex Eustis, Julijana Gjorgjieva and Tyler Seacrest presented 15-minute talks on their senior thesis projects. Robin Baur presented a poster on her senior thesis, while Marie Jameson, Tristan Brand and Greg Minton presented posters on their summer research projects. Both Robin and Greg won prizes for outstanding posters.

Greg Minton Second Place in Problem Solving Competition

Mathematics major Greg Minton '08 received second prize in the National Collegiate Mathematics Championship sponsored by the American Society for Mathematics (ASM), during MathFest in Albuquerque, NM, August 6, 2005.

This is the fourth year in a row that a Mudder has finished first or second in this competition. Last year, Eric Malm '05 finished first, and in the two previous years, second place finishes were earned by Robin Baur '06 and Daniel Boylan '02.





Top to bottom: Owen Lewis '06 and Jason Murcko '06 presenting their posters at a regional MAA meeting held at USC in Spring 2005.

Karl Mahlburg Solves Major Problem in Number Theory

Karl Mahlburg '01 has proved a 60-year old conjecture in number theory. The conjecture was originally postulated in the 1940s by Freeman Dyson, and is based on original work of the famous self-taught mathematical genius Srinivasa Ramanujan. Building on the work of George Andrews and Ken Ono, his graduate advisor at the University of Wisconsin, Karl succeeded in proving the conjecture. Karl's accomplishments received significant media coverage (for example, in *Science* and *Scientific American*) and his paper "Partition congruences and the Andrews-Garvan-Dyson crank" received the first-ever Proceedings of the National Academy of Sciences (PNAS) Paper Prize. Karl completed his Ph.D. in 2006 and is now a C.L.E. Moore Instructor at MIT.

Budapest News

Mudders continue to participate regularly in the Budapest Semesters in Mathematics Program. Recent mathematics majors to spend a semester in Budapest include Sarah Mann and Nick Rauh (Fall 2004); Gregor Passolt and Alexander Eustis (Spring 2005); and Nathan Chenette and Ivan Ventura (Spring 2006).

HMC Ranks 11th in Putnam Competition

The 2004 William Lowell Putnam Mathematical Competition was held on December 4, 2004. Sixty HMC students chose to take this very hard six-hour exam, which requires a unique blend of cleverness and problem-solving skills. Nationwide, 3,733 students competed and found the exam particularly hard this year—the nationwide *median* score this year was 0 out of a total of 120 points. However, 45 of 60 HMC students scored above the median. And, this year, in the team competition, the HMC team of Eric Malm, Jason Murcko '05 and Jeff Hellrung '05 won 11th place out of 515 schools. HMC's outstanding team performance comes on the heels of placing 5th, 6th and 9th in the three previous years (2003, 2002, 2001). In the individual category, three students made the Top 200 List, and 10 HMC students made the Top 500 List, which is a great accomplishment given our school size. Only 10 of the 515 schools that competed could claim more students in the Top 500. Special honors go to the following students: Eric Malm and Jason Murcko who ranked 159.5th, and Brian Rice '08 who ranked 181.5th. The following also landed in the Top 500 List: Nick Rauh '06, Gregory Minton '08, Jeff Hellrung, Alex Eustis '06, Jonathan Azose '07, Reid Howard '06 and Gwen Spencer. In addition, seven more students were within two points of landing in the Top 500.

Carl Yerger Wins Churchill Fellowship

In 2005, Carl Yerger was awarded a Churchill Fellowship for study in the UK. Nationwide, only 11 students were selected for this prestigious scholarship, which is for one year of postgraduate study at the Churchill College of Cambridge University. Carl will study for a Certificate in Advanced Study from the Department of Pure Mathematics and Mathematical Statistics. Carl follows in the footsteps of other mathematical luminaries at Cambridge such as Isaac Newton and Andrew Bernoff. In the past decade, HMC has had seven Churchill winners. After the Churchill fellowship, Carl will begin his graduate study in the Algorithms, Combinatorics and Optimization Program at Georgia Tech.

Julijana Gjorgjieva Awarded Trinity Fellowship

Julijana Gjorgjieva was awarded a Studentship in Mathematics by Trinity College of Cambridge, England. The fellowship provides support to study at Trinity College for one year leading to the infamous Part III of the Mathematics Tripos exam. Notable Trinity Alumni include Sir Isaac Newton, Augustus De Morgan, James Clerk Maxwell, Aleister Crowley, A.A. Milne and Freeman Dyson. After Cambridge, Julijana will continue her graduate studies at Princeton University.

Eric Malm Awarded NDSEG Fellowship

Eric Malm was awarded a National Defense Science and Engineering Fellowship, which awards approximately $31,000 per year for three years of graduate study. Eric will use this award to study mathematics at Stanford University.

Elaine Shaver '09 and Sarah Fletcher '09 presenting a project from Professor Orrison's Discrete Mathematics class during 2006 Presentation Days.

Gwen Spencer Awarded Watson Fellowship

Gwen Spencer '05 has been awarded a Watson Fellowship for one year of post-baccalaureate study outside the United States. Gwen's project "Reinterpreting the Gender of Science and Technology in Emerging Economies" will take her to Tanzania, Swaziland, Kenya, India and Ireland. Following the Watson, Gwen will begin her graduate study in operations research at Cornell University.

NSF Fellowship News

In 2006, five math majors won National Science Foundation Graduate Research Fellowships. The awardees are: Stephanie Moyerman (math and physics '06), Susanna Ricco (math-CS '06), Jeff Jauregui (math '05), Kenny Maples (math and engineering '06) and Michael Vrable (math-CS '04). In addition, five more HMC math majors or alumni won Honorable Mentions: Robin Baur (math '06), Joe Majkut (math '06), Alan Davidson (math-CS '06), Jason Murcko (math '05) and Tim Carnes (math '05). The fellowship provides $30,000 per year plus a $10,500 cost of education allowance for three years of graduate study.

Julijana Gjorgjieva Wins Prize at SACNAS

Julijana Gjorgjieva had the prize-winning mathematics poster at the 2005 Society for Advancement of Chicanos and Native Americans in Science (SACNAS) Conference. Julijana's poster, "Modeling Interaction of Predator and Prey Populations on Dynamic Habitats," involves the development and analysis of an adaptive numerical method for solving a system of partial differential equations on a growing domain and was based on her summer research at HMC with Professor Jon Jacobsen. This marks the second year in a row she has received a prize at SACNAS. In 2004 she had the prize-winning poster for her work "The role of vaccination in the control of SARS," based on research conducted at the Mathematical and Theoretical Biology Institute from Cornell.

HMC Modeling Competition Results

HMC students continue to excel in the Mathematical Contest in Modeling (MCM) sponsored by the Consortium for Mathematics and its Applications (COMAP). Every year thousands of undergraduates and high school students from throughout the world compete in the MCM. In this competition, teams of three must choose between two open-ended real-world modeling problems. Typically one is discrete in nature (combinatorics, graph theory, etc.) and one is continuous in nature (calculus, differential equations, classical physics, etc.). Teams have 96 hours to develop and analyze their model, and type up a comprehensive report. They are allowed to consult only inanimate sources (e.g., books, web pages) during the contest. The team's papers are judged not only on their scientific and mathematical accuracy, but also on their clarity of exposition, insight and creativity. During the same time as the MCM, COMAP also sponsors the Interdisciplinary Contest in Modeling (ICM), which runs under the same rules, but offers a problem of a more interdisciplinary nature.

In 2006, HMC had four MCM teams and three ICM teams. The problems concerned (A) optimal irrigation scheduling for a given field, (B) wheelchair management at airports and (C) policy issues for managing the global HIV/AIDS pandemic. The ICM Problem C had 224 entries, of which only 4 were chosen for top honors Outstanding, including the HMC team of Cris Cecka (math-CS and physics '06), Mike Martin (physics '06) and Tristan Sharp (physics '06). The team analyzed a multistage SIR-type model and explored the infection dynamics under several scenarios, including with and without anti-retroviral treatment (ART), and ART efficacy in the presence of resistant disease strains. Their work was published in the Summer 2006 issue of the *Journal of Undergraduate Mathematics and its Applications*. The team of Benj Azose (math '07), Margeurite Leeds (math-bio '06) and Simon Stump (math-bio '06) earned Honorable Mention.

2006 MCM participants right after the end of the competition (l to r): Jacob Pugh, Tiffany Head, Nick Rauh, Michael Coupland, Kenneth Maples, Tyler Seacrest, Julijana Gjorgjieva, Elisa Celis, Tahir Yusafaly, Margeurite Leeds, Patrick Foley, Steven Erlich, John McCollough, Benj Azose, Simon Stump, Tristan Sharp, Mike Martin, Cris Cecka (not pictured: Herbie Huff, Stephanie Moyerman, Michael Hansen). Be thankful this picture is not scratch-n-sniff!

Left to right: Lori Thomas, Katie Lewis and Clay Hambrick in New Orleans, relaxing after presenting their prize-winning MCM paper.

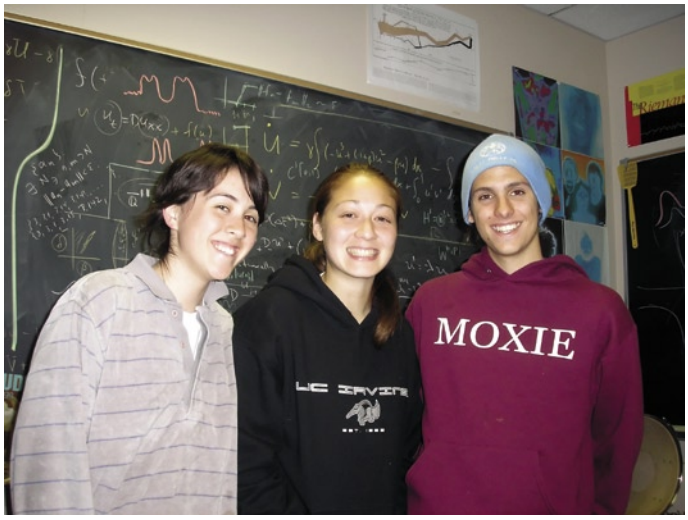
Of the 748 MCM entries in 2006, HMC had three teams earn Meritorious. The Meritorious teams for Problem A were Elisa Celis (math-CS '06), Julijana Gjorgjieva (math '06) and Kenny Maples (math and engineering '06) and Michael Coupland (CS '06), John McCullough (CS '06) and Nick Rauh (math '06). The team of Michael Hansen (math '07), Herbie Huff (math '07) and Stephanie Moyerman (math and physics '06) earned Meritorious on Problem B. Finally, the team of Tiffany Head (math '06), Jacob Pugh (physics '06) and Tyler Seacrest (math '06) earned Honorable Mention for their work on Problem A.

In 2005, a total of 15 HMC students participated in the competition, with problems concerning (A) flood planning downstream of Lake Murray in central South Carolina; (B) optimizing tollbooths on a highway barrier-toll plaza; and (C) modeling and management of a nonrenewable/exhaustible resource. The MCM had 664 entries, of which only 10 were honored as Outstanding, including the HMC team of Clay Hambrick (physics '05), Katie Lewis (math '05) and Lori Thomas (math-bio '05). The team, which chose Problem A, also earned the SIAM (Society for Industrial and Applied Mathematics) Prize, which includes a cash award of $300 per team member, three one-year student memberships in SIAM, and travel support to present their work at the national SIAM Meeting, which was held in New Orleans in July 2005. Additionally, their paper, "From Lake Murray to a Dam Slurry," which models the extent of damage that might be caused due to a breach in the Lake Murray Dam (in South Carolina) was published in the Fall 2005 issue of the *Journal of Undergraduate Mathematics and its Applications*.

This was Lori's third time competing, and her second time being on an Outstanding team. This was also Katie and Clay's second time competing, although for Clay the other time he competed in the MCM was when he was in high school!

We also had three teams earn Meritorious (top 10 percent): Steven Avery (math and physics '05), Tim Carnes (math '05) and Eric J. Malm (math '05); Benj Azose (math '06), Alan Davidson (math-CS '06) and Julijana Gjorgjieva (math '06); Lia Corrales (physics '06), Michael Coupland (CS '06) and Nick Rauh (math '06).

HMC leads all other colleges and universities in the number of ICM and MCM Outstanding awards won, and 2006 marks the ninth year in a row that HMC has had at least one team earn Outstanding in the competition! Of course, the name HMC plays no role in the judging—teams are assigned numbers at the start of the contest and judges do not know which schools are connected to which numbers until after the final decisions have been made. So each win is truly earned.



Herbie Huff, Stephanie Moyerman and Michael Hansen looking forward to some sleep after completing the MCM.

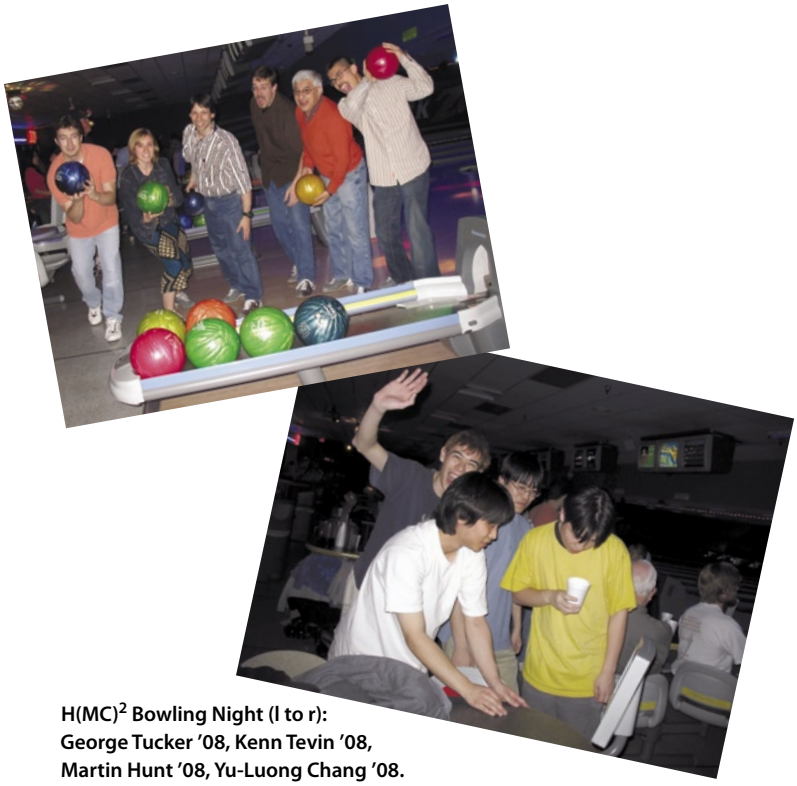
Julijana Gjorgjieva, Elisa Celis and Kenneth Maples presenting their MCM work during 2006 Presentation Days.

H(MC)^2 Report

Last year, the Harvey Mudd College Math Club H(MC)^2 enjoyed an increase in activities and participating members. During the 2005–2006 academic year there were over 40 registered members of the math club. Members participated in exciting events that facilitated social interaction with the mathematics professors while also providing an opportunity for those interested in math to interact with each other in a non-academic setting. H(MC)^2 kicked off the year by organizing the annual math BBQ. The math BBQ was a striking success and attracted potential math majors and math clubbers.

During the 2005 fall semester H(MC)^2 challenged the CMC math club to a game of softball. Unfortunately Mudd's mathletes were conquered by the ferocious CMCers, but the mathletes didn't go down without a fight! Fortunately for the math club, it only got better as the year progressed. Math club members also attended the Pepperdine math formal where they got the chance to strut their dance moves with fellow mathematicians from the greater L.A. area. The Math Clubers also enjoyed an exciting night of bowling with the math profs. On several occasions H(MC)^2 merged forces with FNMG (Friday Night Movie Guys) to screen some movies that have popularized mathematics in main-stream society. H(MC)^2 had a superb year filled with fun and adventures, and it is rumored that this is only a foreshadowing of the excitement that will come during the 2006–2007 academic year.

—Parousia Rockstroh '08, H(MC)^2 vice president



H(MC)^2 Bowling Night (l to r): George Tucker '08, Kenn Tevin '08, Martin Hunt '08, Yu-Luong Chang '08.

Every HMC mathematics-related major has a capstone research experience through either the Clinic Program or the Senior Thesis program. In either case, students spend the year immersed in a research problem. The Senior Thesis program offers the student, guided by a faculty member, a chance to experience a taste of the life of a professional research mathematician. The work is largely independent with guidance from the research advisor. Throughout the year thesis students meet together weekly to learn fundamental research skills as well as to give presentations on their work to each other. Here is a complete list of the thesis projects undertaken over the last two years. Electronic versions of the theses are available at the web-site http://www.math.hmc.edu/seniorthesis/.

2004–05 Senior Theses

Ruben Arenas
Constructing a Matrix Representation of the Lie Group G_2
Advisor: Weiqing Gu

Steven Avery (Math/Physics)
Noncommutative Geometry
Advisor: Vatche Sahakian (Physics)

Tim Carnes
Permutation Routing in the Hypercube and Grid Topologies
Advisor: Ran Libeskind-Hadas (CS)

Zajj Daugherty
An Algebraic Approach to Voting Theory
Advisor: Michael Orrison

Jeff Jauregui
Solving for Volume-Minimizing Cycles in G_2-Manifolds
Advisor: Weiqing Gu

Akemi Kashiwada
Constructing Phylogenic Trees from Subsplits
Advisor: Francis Su

Owen Lewis
Generalized Julia Sets: An Extension of Cayley's Problem
Advisor: Jon Jacobsen

Eric Malm
Decimation-in-Frequency Fast Fourier Transforms for the Symmetric Group
Advisor: Michael Orrison

Jason Murcko
Cesaro Limits of Analytically Perturbed Stochastic Matrices
Advisor: Henry Krieger

Gwen Spencer
Combinatorial Consequences of Relatives of the Lusternik-Schnirelmann-Borsuk Theorem
Advisor: Francis Su

Kathe Todd-Brown
Mathematical Modeling of Local Tumor Morphology with Chemotherapy and Immune Treatments
Advisor: Lisette de Pillis

Carl Yerger
Extensions of Graph Pebbling
Advisor: Francis Su

2005–06 Senior Theses

Robin Baur
The Analysis of Rupture in Thin Fluid Films
Advisor: Andrew Bernoff

Deborah Berg
Connections Between Voting Theory and Graph Theory
Advisor: Francis Su

Tristan Brand
A Fast Fourier Transform for the Symmetric Group
Advisor: Michael Orrison

Alexander Eustis
The Negs and Regs of Continued Fractions
Advisor: Arthur Benjamin

Julijana Gjorgjieva
Turing Pattern Dynamics for Spatiotemporal Models with Growth and Curvature
Advisor: Jon Jacobsen

John Hearn
Kolmogorov Complexity of Graphs
Advisor: Ran Libeskind-Hadas (CS)

Joesph Majkut
Investigation of Swarming Behavior
Advisor: Andrew Bernoff

Kenneth Maples
Optimal Control of a Building During an Earthquake
Advisor: Weiqing Gu

Jessica May
Matrix Representations of Knot and Link Groups
Advisor: Jim Hoste (Pitzer)

Stephanie Moyerman (Math/Physics)
Giant Magnetoresistance and Polarized Neutron Reflectometry Studies of Spin Valves with Pico-Scale Antiferromagnetic Layers
Advisor: Jim Eckert (Physics)

Tracy Powell
The Singular Values of the Exponentiated Adjacency Matrices of Broom-Tree Graphs
Advisor: Lesley Ward

Nikolas Rauh
An Exploration in Subtropical Algebra
Advisor: Francis Su

Tyler Seacrest
Mathematical Models of Image Processing
Advisor: Weiqing Gu

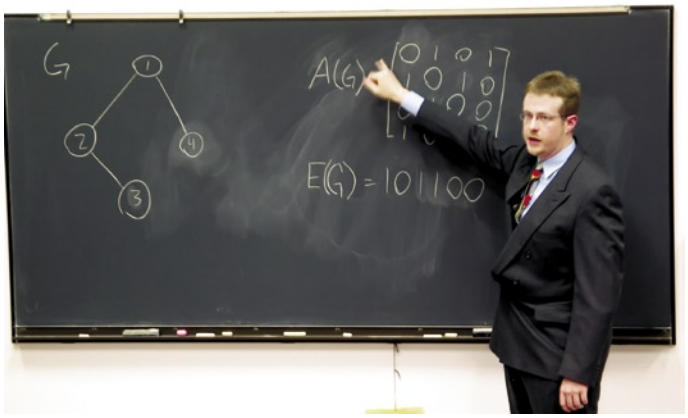
Elan Segarra
An Exploration of Riemann's Zeta Function and its Application to Prime Number Distribution
Advisor: Michael Raugh and Darryl Yong

Simon Stump
Succession, Invasion and Coexistence: PDEs in Ecology
Advisor: Jon Jacobsen

Tracy Powell next to her senior thesis poster during Presentation Days.

Jessica May, with thesis advisor Professor Jim Hoste (Pitzer), next to her senior thesis poster during Presentation Days.

2006 Math Senior Dinner (l to r): Professor Susan Martonosi, Julijana Gjorgjieva, Kenneth Maples, Elisa Celis, Garret Heckel, Dr. Shenjun Jiang, Professor Weiqing Gu.



John Hearn presenting during Presentation Days.

Seniors attending Professor Benjamin's show at the Magic Castle in December 2005.

Departmental reception for graduating seniors (l to r): Simon Stump, Dr. Harriet Maccracken, Professor Jon Jacobsen, Dr. Edmund Stump.

Professor Francis Su with Nick Rauh and Isabelle Rauh at graduation.

The mathematics department continues to offer innovative Clinic experiences for Mudders under the leadership of Professor Michael Raugh. Each year the department awards the Robert Borrelli Clinic Prize to one or more clinic teams that distinguish themselves for making outstanding contributions to the Mathematics Clinic. During the 2004–05 academic year both teams received the prize and in 2005–06 the Cardinal Health team received the prize.

Automated Analysis of Gene Expression Data (2004–05)

Sponsor: Applied Biosystems
Team Members: Jeff Brenion, Kevin Krogh, Theresa Poindexter, Ryan Riegel
Advisor: Henry Krieger
Abstract: Biologists use a technique called real-time polymerase chain reaction (PCR) to collect gene expression data in large quantities. A potential use of this data is to help determine genes that reliably classify samples; however, complications can arise when the amount of data is large. Extracting information from large data sets often requires sophisticated mathematical techniques. We explore several methods, focusing our efforts on principal component analysis and ΔC_t values, or measures of relative gene expression levels. Our current work involves several data sets, including studies regarding lymphoma, leukemia and cranial mutations in mice. While none of our techniques identify genes that reliably classify patients in the lymphoma data set, we observe promising results with many of our techniques on the other data sets.

Printer Drift and Recalibration (2004–05)

Sponsor: Hewlett-Packard Labs
Team Members: Brianne Boatman, Durban Frazer Jeff Hellrung, Katie Lewis
Advisor: Weiqing Gu
Abstract: Today's digital color printers achieve a wide gamut of colors from the overlay of three to eight layers of ink. Ink is placed on the substrate/paper in different amounts to create a huge array of color mixtures. A standard procedure is to create a 3-D lookup table to determine the amounts of each ink that will produce a chosen color. This table is constructed by printing up to thousands of ink combinations on a chosen substrate/paper and measuring the resulting colors via a spectrophotometer. This information is used to plot the ink combinations within an internationally recognized color coordinate system, and then a regular grid of points is interpolated within this coordinate system to produce the lookup table.

Changes in temperature, paper quality, substrate, and even "printer drift" affect how varying ink combinations behave with one another, resulting in the lookup table no longer being accurate. A new lookup table must then be produced to recalibrate the printer. We intend to investigate ways to make this recalibration more efficient than current solutions.

Control Algorithm for an IV System (2005–06)

Sponsor: Cardinal Heath
Team Members: Reid Howard, Sarah Mann, Susanna Ricco, Hope Runyeon
Advisor: Andrew Bernoff
Abstract: Many of the most critical medications are injected directly into veins, arteries or muscles using an IV system. The flow through traditional IV systems is driven by direct displacement mechanisms such as pistons or peristaltic actuators with flow disruption detected by measuring pressure. Cardinal Health's next generation of systems will combine active and passive components with a sensor (a current HMC Engineering Clinic project) that determines the instantaneous flow rate. The mathematics team designed a control algorithm that incorporates feedback from this sensor to more accurately regulate flow.

Cardinal Health Team (l to r): Hope Runyeon, Susanna Ricco, Sarah Mann, Reid Howard.

2005–06 Hewlett-Packard Team (l to r): Garret Heckel, Benj Azose, Ian Win, Jed Levin, Eric Johnson.

Implementation and Testing of Two New Methods for Generating ICC Profiles (2005–06)

Sponsor: Hewlett-Packard Labs
Team Members: Benj Azose, Garret Heckel, Eric Johnson, Jed Levin, Ian Win
Advisor: Weiqing Gu
Abstract: Regardless of the technology used, the end goal of printing is to produce an output document that pleasingly resembles the input as much as possible. This can be reproducing a photograph, printing a computer screen, or even making two copies of a document as similar as possible. When working with only two devices, the transition between them can be studied exhaustively, but in the general case, we want a tool to make this transition easier. This is accomplished by mapping from an individual machine's range of colors (like a monitor's RGB space) to a device independent color space, and is called an ICC profile. At present, while the profile itself is well defined, the inverse transform is very difficult to produce and can have a lot of error from the way it is created. Our project is the design and implementation of two new methods which use dramatically different techniques to generate ICC profiles.

Advanced Modeling of Renewable Energy Market Dynamics (2005–06)

Sponsor: National Renewable Energy Laboratory
Team Members: Moana Evans, Rob Little, Kevin Lloyd, Gregor Passolt, George Malikov
Advisor: Patrick Little (Engineering) and Michael Raugh
Abstract: Renewable energy technologies, particularly solar and wind, have sustained growth rates of 20–30% per year for the past three decades. However, these high growth rates have not translated into significant gains in market penetration, due to the very small base, except for specific geographic markets such as in Europe. Techniques for analysis of market growth, penetration and forecasting, while satisfactory for consumer technologies (e.g. cell phones, refrigerators and TVs), are not widely applicable to renewable energy technologies for which free-market analysis cannot be applied. Specifically, renewable energy penetration is subject to technology "lock in," regulatory rules, oligopoly control (in certain geographic markets) and fiscal policy. This project seeks to address these issues by first researching and classifying current models used for predicting market penetration, and second, by adapting a selected model to account for the differences in modeling consumables and energy technologies, and to predict the effects of government policy options on innovation and market adoption.

Los Alamos Team (l to r): Dana Mohamed, Cristopher Cecka, Tiffany Head, Alan Davidson, Liam Robinson.

Mathematical and Computational Modeling of Tumor Development (2005–06)

Sponsor: Los Alamos National Laboratories
Team Members: Cristopher Cecka, Alan Davidson, Tiffany Head, Dana Mohamed, Liam Robinson
Advisor: Lisette de Pillis
Abstract: Computerized mathematical models that accurately reflect the biological processes of tumor growth can help increase understanding of cancer biology and potentially improve cancer treatment. Furthermore, such models can be used as predictive tools for studying the effects of chemotherapies upon tumor growth and creating more effective and precisely calibrated treatments. In order to study chemotherapy on tumors, our team explored vascular tumor growth by adding a blood vessel network to a pre-existing avascular tumor model in several stages. We first tested a simple vein structure and then implemented more complex vein structures. We will next study the effects of various chemotherapy doses upon tumor growth.

NREL Team (l to r): George Malikov, Gregor Passolt, Rob Little, Moana Evans, Kevin Lloyd.

Giovanni Borrelli Mathematics Fellowship

awarded to rising senior mathematics students who have distinguished themselves scholastically and show promise of contributing in an important way to the mathematical sciences

2006: Julijana Gjorgjieva, Tyler Seacrest
2005: Eric Malm

Stavros Busenberg Prize

awarded to rising senior students who show particular promise in the study of applied mathematics

2006: Robin Baur
2005: Jeffrey Hellrung

Chavin Prize

awarded to HMC students who author exemplary papers in the area of the mathematical sciences

2005: Eric Malm, Jason Murcko

Courtney S. Coleman Prize

awarded to two rising juniors who excel in mathematics

2005: Marie Jameson, Holly Johnsen

Robert James Prize

awarded to two rising sophomores who excel in mathematics

2005: Greg Minton, Kenji Yoshida
2004: Jonathan Azose, Fang-Yuan Chang

RIF Scholarship

awarded each year to incoming HMC students who demonstrate exceptional mathematical ability, possibly evidenced by strong performance in mathematical competitions

2005: Carl Gaebler
2004: Gregory Minton, Brian Rice

Christopher Cecka, Tristan Sharp and Mike Martin speaking during 2006 Presentation Days.

RIF Prize

awarded to the top three HMC students on the William Lowell Putnam Mathematical Competition

2005: Eric Malm, Jason Murcko, Brian Rice
2004: David Gaebler, Andrew Niedermaier, Jason Murcko, Jeff Hellrung

Jayaweera Prize

awarded for outstanding performance in the annual Interdisciplinary Competition in Modeling

2006: Cris Cecka, Mike Martin, Tristan Sharp

A complete list of past winners can be found at http://www.math.hmc.edu/program/awards/.

Pictures from the department's reception for graduating seniors: (top) Julijana Gjorgjieva and Eileen Cronin, (bottom) Robin Baur and family.

FunFact

St. Petersburg Paradox

A new casino offers the following game: you toss a coin until it comes up heads. If the first heads shows on the *N*th toss, you win 2*N* dollars. (Thus the payoff doubles with each coin toss that isn't heads.)

How much should you be willing to pay to enter this game?

At first glance, you might think it is the expected value of the payoff to the player. But if you calculate it, you get a divergent series... the expected value is infinite!

If so, then maybe you should be willing to pay any fixed finite amount of money to play this game? And yet the chance of winning more than 4 dollars is only 1/4, so that can't be right, can it?

To learn about this paradox and other Fun Facts, check out http://www.math.hmc.edu/funfacts/.

Susan Martonosi

Susan Martonosi joined the Department of Mathematics in Fall 2005, having received her Ph.D. in operations research from MIT and her B.S. in operations research and industrial engineering from Cornell University. Her research explores the mathematical modeling of problems in homeland security to improve both the security and operational efficiency of the system. She has conducted research at the RAND Corporation, and serves as a consultant to the Homeland Security Institute. Her broader interests are in using operations research for problems in the public interest, such as health, education, environment and public safety.

Martonosi was a Peace Corps volunteer from 1999–2001 in the Republic of Guinea, West Africa, where she taught mathematics in a rural high school. In her free time, she enjoys running, swimming and playing Senegalese drums. Starting in 2006, she will be the faculty-in-residence at Sontag Residence Hall.

Danny Goroff

Daniel L. Goroff, professor of the practice of mathematics and member of the faculty at Harvard University since 1983, has been named dean of the faculty at Harvey Mudd College and professor of mathematics and humanities.

Goroff earned his B.A. and M.A. degree summa cum laude at Harvard as a Borden Scholar, an M.Phil. in economics at Cambridge as a Churchill Scholar, and a Ph.D. in mathematics at Princeton as a Danforth Fellow.

During his tenure at Harvard, Goroff has distinguished himself as a leader in mathematics and science education, and in its advocacy. In addition to his faculty roles, he served as associate director of the Derek Bok Center for Teaching and Learning and as a tutor at Harvard's Leverett House. He currently chairs the U.S. National Commission on Mathematics Instruction at the National Research Council and co-directs the Sloan Scientific and Engineering Workforce Project based at the National Bureau of Economic Research.

Goroff's advocacy for scientific education and research has also taken him to Washington, D.C., where he worked for the National Research Council as a division director in 1996–97, and for the President's Science Advisor at the White House Office of Science and Technology Policy in 1997–98.

A 1988 Phi Beta Kappa Teaching Prize winner, Goroff has taught courses for the departments of Mathematics, Economics, Physics, and History of Science at Harvard. In pursuing his work on nonlinear systems, chaos and decision theory, he has held visiting positions at the Institut des Hautes Études Scientifiques in Paris, the Mathematical Sciences Research Institute in Berkeley, Bell Laboratories in New Jersey and the Dibner Institute at MIT.

NSF News

Francis Su was awarded a National Science Foundation (NSF) Research Grant of $146,640 for 2003–2006, for a project entitled "Combinatorial Fixed Point Theorems, Polytopes and Fair Division." The grant has supported the research of several students: Gwen Spencer '05, Tyler Seacrest '06, Debbie Berg '06, Alex Iszak '07 and Douglas Rizzolo '08. The project involves the study of several mathematical problems motivated by questions in economics and the social sciences, and it also provided travel support to facilitate the collaboration of Su with mathematical economist Claus-Jochen Haake at the University of Bielefeld, Germany. Haake spent three months in 2004 and one month in 2006 visiting Harvey Mudd College, and co-authored a paper with Su and Akemi Kashiwada '05.

The NSF has also awarded $460,651 to The Claremont Colleges to establish Robert Noyce Scholarships for undergraduates majoring in science, mathematics and engineering who will agree to teach in high-need public schools after graduating. The scholarships can be used by students in their last year of college and in their first year of the teacher education program at Claremont Graduate University. David Drew (CGU School of Education faculty) was the principal investigator for the grant. Darryl Yong '96 was the co-principal investigator. In conjunction with the Career Services Office, Darryl has also been serving as an advisor to HMC students considering careers in education.

Art Benjamin's Sabbatical Report

In Fall 2004, I spent the first half of my sabbatical in Boston, doing combinatorics research at Brandeis University. Since I had no teaching obligations, I wrote several papers, attended several conferences (including an International Conference on Fibonacci Numbers held in Germany) and gave more than 25 research talks. I was also finishing my first year as co-editor of *Math Horizons* magazine. The highlight for me was coming up with an original combinatorial proof of Vandermonde's determinant, which I presented at the MIT Combinatorics Seminar, and will soon appear in the *American Mathematical Monthly*. I also presented my mathemagics show at "a number of" places, including an off-Broadway production of "Monday Night Magic." As a result of attending one of my shows, an editor from *Reader's Digest* wrote about me in their "Best of America" May 2005 issue.

Then in the spring of 2005 (or was it the fall of 2005?) my family and I went to Sydney, Australia, based at the University of New South Wales. Again, since I had no teaching duties, we were free to travel and really took advantage of that. Although I presented many research talks and mathemagics performances (including Australia's "Today Show," "Saturday Disney" and other talk shows), the real treat was seeing so many fun and beautiful parts of Australia. I will always remember the starriest night I've ever seen on Kangaroo Island, scuba diving the Great Barrier Reef, and my first (and last!) bungee jump at the Gold Coast.

Other Faculty News

Andrew Bernoff continues to take a group of HMC students with him to conduct applied mathematics research at UCLA every summer. Research topics include modelling the swarming of insects and the spread of crime. This program was recently supported for the next five years as part of a $1.32 million Research Training Grant from the National Science Foundation.

Alfonso Castro served as member of the doctoral dissertation committees of Hugo Aduen and Sigifredo Herron (Universidad Nacional de Colombia), and Alfredo Cano and Eric Hernandez (UNAM-Mexico). He also gave invited talks at "The Meeting on Variational Methods" (Guanajuato, Mexico) in December of 2005, and at the "Workshop on Nonlinear Differential Equations" in Como (Italy), September 11–15, 2006.

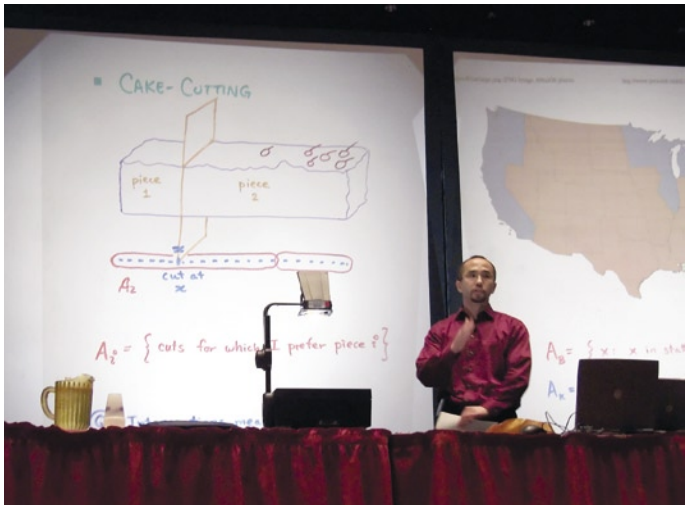
Jon Jacobsen was named the Howard and Iris Critchell Assistant Professor for the 2005–07 academic years. He published the papers "Generalized Julia Sets and Continuous Newton's Method" in collaboration with Owen Lewis '04 and Brad Tennis '05, in the Electronic Journal of Differential Equations and "An Adaptive Numerical Method for Modeling Species Interactions on Dynamic Habitats" in collaboration with Julijana Gjorgjieva '05 and Larry Li (UCR), in Ecological Complexity. He gave a research talk at the Sixth Annual Mississippi State Differential Equations Conference, and co-chaired a panel discussion "Speaking of Mathematics" at the 2005 Annual Joint Meeting in Atlanta. He continues to advise a team of Mudders who are participating in NASA's Microgravity Program.

Art, Deena, Laurel and Ariel Benjamin with friends.

Darryl Yong has attended the Park City Mathematics Institute each summer since 2002, primarily to serve as a facilitator for the Secondary School Teachers Program. He served as an advisor for a CGU Clinic on the modeling of quantum effects in decanano semiconductors. He also continues to play chamber music with students and other faculty members. Most recently, he performed the Brahms Piano Quintet on a Friday Noon Concert in October 2005, and accompanied Gregor Passolt '06, a violinist, on his senior recital.

Lesley Ward received the 2006 Henry L. Alder Award for Distinguished Teaching by a Beginning College or University Mathematics Faculty Member from the Mathematical Association of America (MAA). The award is given to faculty members whose effectiveness in teaching undergraduate mathematics has had influence beyond their own classroom. Francis Su was a past recipient of this award in 2004.

Michael Orrison published "Reflections acting efficiently on a building" in *Forum Mathematicum*, and "The linear complexity of a graph" (with David Neel from Seattle University) in the *Electronic Journal of Combinatorics*. In the summer of 2005, he gave an invited talk at the Erwin Schrödinger International Institute for Mathematical Physics in Vienna, and he gave a series of four lectures to the participants in the James Madison University Research Experience for Undergraduates (REU) program. During the summer of 2006, he was an advisor for The Claremont Colleges Mathematics REU. He continues to enjoy being a part of the department's outreach program, Pathways, through which he has spoken to over 1,000 local high school students over the last two years. (For information about Pathways, see http://www.math.hmc.edu/pathways/.)



Francis Su giving a plenary talk entitled "Preference Sets, Graphs and Voting in Agreeable Societies" at the 2006 Joint AMS-MAA meeting in San Antonio. (Photo courtesy of Michael Moody.)

Francis Su continues to work on problems at the intersection of geometric combinatorics and the social sciences. His work with Adam Bliss '04 on "Lower bounds for simplicial covers and triangulations of cubes" appeared in *J. Discrete Comput. Geometry* and established that the minimal triangulation of the 4-dimensional cube is size 16. He also published a paper with Tim Prescott '02 on "A constructive proof of Ky Fan's generalization of Tucker's lemma" that appeared in *J. Combin. Theory Ser. A*. Su spoke about his new work with Debbie Berg '06 on applications of Helly's Theorem to voting problems in an invited address at the 2006 Joint Winter Meetings in San Antonio, Texas. This year, Su was appointed to the editorial board of the *American Mathematical Monthly*, and his paper with Gwen Spencer '05, entitled "The LSB theorem implies the KKM lemma," will appear in the February 2007 issue of that journal.

Susan Martonosi's research this year has focused on developing operations research models to study how terrorists might be deterred by security measures. She has worked with three students (Eugene Quan '07, Daniel Walton '07 and Minal Shankar '08) on these models. She had a chapter published in *The Economic Impacts of Terrorist Attacks* (H.W. Richardson, P. Gordon, J.E. Moore, II, eds.) entitled "Evaluating the viability of 100 per cent container inspection at America's ports" (H.H. Willis, D.S. Ortiz, co-authors). She was also invited to speak at a workshop sponsored by the Homeland Security Institute on Advancing Analytic Techniques in Deterrence Analysis, which led to a consulting project with HSI. In June, she was named a Project NExT (New Experiences in Teaching) Fellow by the MAA and attended the Project's week-long teaching workshop in Knoxville, TN in August.

Lisette de Pillis continues to work in the area of modeling cancer growth and treatment. She published the article "A Validated Mathematical Model of Cell-Mediated Immune Response to Tumor Growth" (with Ami Radunskaya from Pomona College and Dr. Charles Wiseman from St. Vincent Medical Center) in *Cancer Research*, one of the most widely read medical journals. This research has involved several Mudders including Lindsay Crowl '04, Katherine Todd-Brown '04, Lorraine Thomas '05, Michael Vrable '04, William Chang '04 and Eric Malm '05.

Also in collaboration with Radunskaya and Wiseman, she organized a workshop for medical and mathematical researchers on the modeling of tumor and immune dynamics, which was held in December 2005, funded by the American Institute of Mathematics. Participating in this meeting were leading names and award-winners in tumor-immunology research, a founder of a bio-tech firm in Israel, and mathematicians of all backgrounds. She also continues to work on the NSF funded project "Mathematical

Modeling of the Chemotherapy, Immunotherapy and Vaccine Therapy of Cancer" on which she is principal investigator along with Professors Weiqing Gu and K. Renee Fister (Mathematics, Murray State University). The aim of the project is to draw on the expertise from the three researchers in the areas of mathematical modeling and computation, differential geometry, and optimal control to develop mathematical tools applied to the creation and testing of new combination cancer chemo-immunotherapies. This work has involved several undergraduates at Mudd including Kenji Yoshida '06, Tiffany Head '06, Kenneth Maples '06, James Moore '07, David Gross '08 and Benjamin Preskill '09. In July 2005, de Pillis taught a three-week course "An Introduction to Cancer Modeling with Optimal Control" at the Park City Mathematics Institute sponsored by the Institute for Advanced Study at Princeton. Throughout the year she gave 16 invited presentations to a wide variety of audiences on her research and also the mathematical biology program at HMC. She also served as Clinic advisor for a project sponsored by the Los Alamos National Laboratory (LANL) entitled "Modeling Vascular Tumor Growth" and served on the HMC Presidential Search Committee.

Art Benjamin receiving the Beckenbach Book Prize at the 2006 Joint AMS-MAA meeting in San Antonio, for his book *Proofs That Really Count: The Art of Combinatorial Proof*, which he co-authored with Jennifer Quinn, executive director of the Association for Women in Mathematics. (Photo courtesy of Michael Moody.)

Lori Thomas '05 (math-bio) is entering the MIT Woods Hole Institute graduate program in biological oceanography. **Richard Jones** '72 (math) is currently the United States Ambassador to Israel. **Elisha Peterson** '00 (math) earned his Ph.D. at University of Maryland, College Park and is now an assistant professor at West Point Academy. **Joel Miller** '00 (math) is beginning a postdoc at Los Alamos after completing his Ph.D. at Cambridge. He also was married to Anja Slim last summer. **Marco Latini** '01 (math) anticipates graduating from the California Institute of Technology in Fall 2006; he is starting a job with CNA Corporation. **Tara Martin** '04 (math-bio) is starting the graduate program in systems biology at Harvard; she has spent the past year studying mathematical epidemiology with Sally Blower at UCLA. **Greg Rae** '00 (math-CS) has left Google and is working on a new start-up. On April 5, 2006, Greg gave a talk at HMC entitled "The Google Zeitgeist: Finding Trends in a Sea of Data" as part of the Dr. Bruce J. Nelson '74 Distinguished Speaker Series. Greg has also recently joined the HMC Board of Trustees.

Alumni, please e-mail us your news for the next issue at muddmath@math.hmc.edu.

An old photo from the archives... Can any of you help to identify these alumni? Send a note to muddmath@math.hmc.edu.

Julia-set-inspired tattoo.

Arthur Benjamin, *Professor* (Ph.D., Johns Hopkins University): combinatorics, game theory, number theory.

Andrew Bernoff, *Professor* (Ph.D., Cambridge University): applied mathematics, fluid mechanics, free boundary problems, self-similarity.

Alfonso Castro, *Kenneth A. & Diana G. Jonsson Professor and Department Chair* (Ph.D., University of Cincinnati): partial differential equations, nonlinear functional analysis.

Lisette de Pillis, *Professor* (Ph.D., University of California, Los Angeles): numerical linear algebra, computational fluid dynamics, mathematical biology.

Daniel Goroff, *Professor of Mathematics and Humanities, Dean of the Faculty* (Ph.D., Princeton University): dynamical systems, Hamiltonian mechanics, mathematical history, philosophy, education.

Weiqing Gu, *Professor* (Ph.D., University of Pennsylvania): differential geometry, topology, optimal control, geometric modeling, computer-aided geometric design.

Jon Jacobsen, *Howard & Iris Critchell Assistant Professor* (Ph.D., University of Utah): nonlinear analysis, partial differential equations, mathematical biology.

Susan Martonosi, *Assistant Professor* (Ph.D., Massachusetts Institute of Technology): operations research, applied probability, aviations security.

Michael Orrison, *Assistant Professor* (Ph.D., Dartmouth College): algebra, combinatorics, computational noncommutative harmonic analysis.

Michael Raugh, *Professor and Director of the Mathematics Clinic* (Ph.D., Stanford University): scientific computing, mathematical modeling.

Francis Su, *Professor* (Ph.D., Harvard University): topological and geometric combinatorics, fair division, mathematical economics.

Lesley Ward, *Associate Professor* (Ph.D., Yale University): complex analysis, Web search, harmonic analysis.

Darryl Yong '96, *Avery Assistant Professor* (Ph.D., University of Washington): perturbation theory, numerical analysis, ordinary and partial differential equations.

Suzanne Frantz, *Department Administrative Aide*

Barbara Schade, *Mathematics Clinic Administrative Aide*

Claire Connelly, *Systems Administrator*

Visiting Faculty

Recent visitors to the faculty include Yixin Guo (Ph.D., University of Pittsburgh), Seema Nanda (Ph.D., Courant Institute of Mathematical Sciences, New York University) and Elissa Schwartz (Ph.D., Courant Institute of Mathematical Sciences, New York University), all of whom were supported by the Quantitative Life Sciences Program, administered by Lisette de Pillis and Stephen Adolph (HMC biology).

2005 math department retreat at the Kriegers' Dana Point home (l to r): John Milton, Hank Krieger, Francis Su, Art Benjamin, Alfonso Castro, Darryl Yong, Lisette de Pillis, Lesley Ward, Susan Martonosi, Suzanne Frantz, Andy Bernoff, Weiqing Gu, Jon Jacobsen, Michael Orrison, Danny Goroff.

New Compute Server

At the end of the summer, Professor Lisette de Pillis and HMC's Center for Quantitative Life Sciences purchased a new compute server for use by the center and the department. Hex—named after the computer assembled by the Department of High Energy Magic in Terry Pratchett's *Discworld* novels—has eight dual-core AMD processors, giving us sixteen processor cores in total and 32 GB of RAM. The machine was purchased through generous funding of the Center for Quantitative Life Sciences through the W. M. Keck Foundation Center. It should enter service by the beginning of the spring semester, in time for our scientific computing, thesis and Clinic students to give it a workout!

Senior Thesis (and Maybe Clinic) Archives

Sharing the work of our thesis students is both a valuable contribution to academia and a great advertisement for the college and the department. To stay within the lines of copyright legislation, we are now asking students to sign a copyright form that gives the department the right to share their work for academic purposes.

If you wrote a thesis prior to last year, we would greatly appreciate it if you could take the time to download the form from http://www.math.hmc.edu/seniorthesis/tools/deposit-agreement.pdf, fill it in and mail it back to us. (Also, if you wrote a thesis and it's not currently available on our web-site (under http://www.math.hmc.edu/seniorthesis/archives/, please send us an electronic copy and we'll add it!)

We're switching to a more formal permission process because we're considering moving our thesis archive to The Claremont Colleges Digital Library (http://ccdl.libraries.claremont.edu/), which has strict requirements for the materials in its collection.

We are also exploring the possibility of making Clinic reports available online, once the time limits in the contracts signed with sponsors have been met. Clinic reports form a valuable resource for current Clinic students and for others exploring similar problems, so we hope to be able to make that happen.

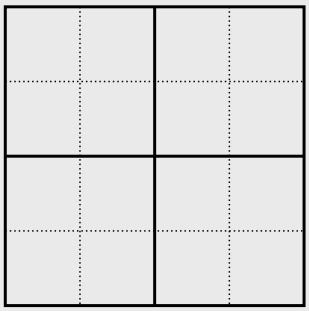
Donations Welcome!

Meanwhile, our scientific-computing lab continues to age into obsolescence. The machines (mostly 1.7 GHz Pentium 4s) are adequate for basic instructional purposes, but are no longer ideal for the sorts of computationally intensive uses they've been put to in the past. New systems such as hex and the Amber cluster help cover some of the gaps, but newer, faster workstations would help both instruction and research. If you or your company have money looking for a good home, we'd be happy to help!

Claire Connelly holds an undergraduate degree in anthropology, is a Debian Developer, and has been a GNU Emacs and MH user since 1990. She edited George Grätzer's First Steps in LaTeX *in 1999 and the third edition of* Math into LaTeX *in 2000.*

Bernoff's Puzzler

Consider a 4×4 sudoku puzzle, in which all of the numbers 1 through 4 must appear once in every row, column and quadrant, as shown below. What is the maximum number of known entries so that the puzzle will allow for more than one solution? What is the minimum number of known entries that can determine a unique solution?



Send your answers to ajb@hmc.edu.

Ben Stanphill '07 and Professor Orrison watching on as Victor Camacho '06 (middle) busts a move at Pepperdine's Open Ball Math Formal in 2005.

HMC Mathematics Conference Series

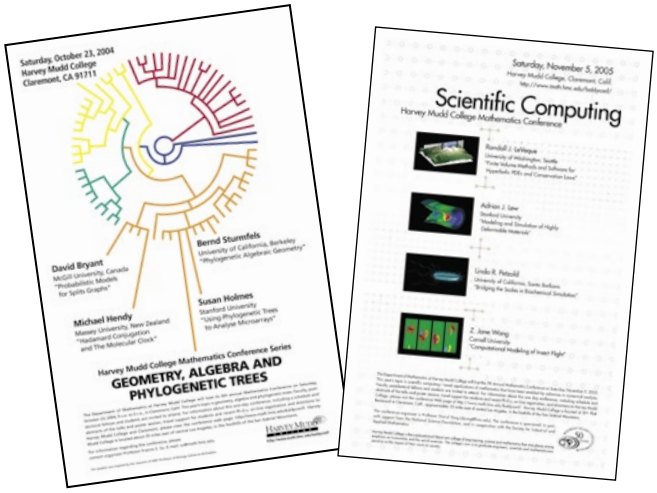
On October 23, 2004, Harvey Mudd College hosted the sixth annual HMC Mathematics Conference (formerly known as the Mt. Baldy Conference) on Geometry, Algebra and Phylogenetic Trees. The conference was organized by Professor Francis Su and focused on mathematical methods to reconstruct phylogenetic trees (e.g., a "tree of life" representing relationships between species) from data (e.g., genomic data). A list of plenary speakers and the titles of their talks follows.

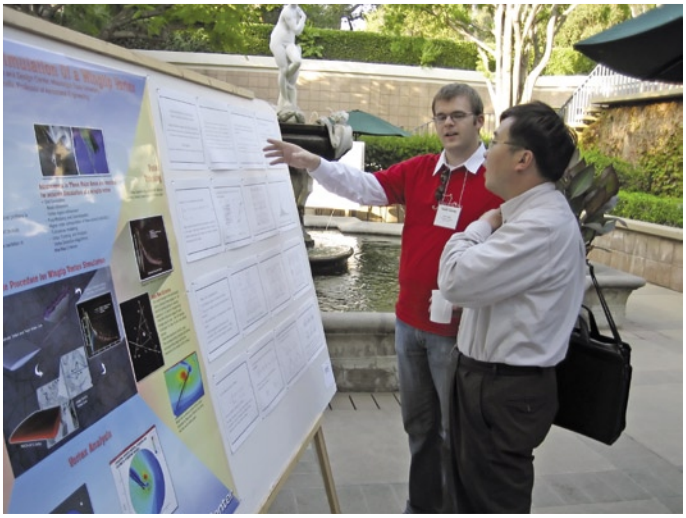
Michael Hendy (Massey University, New Zealand)
"Hadamard conjugation and the molecular clock"

Susan Holmes (Stanford University)
"Using Phylogenetic Trees to Analyse Microarrays"

David Bryant (McGill University, Canada)
"Probabilistic models for Splits Graphs"

Bernd Sturmfels (UC Berkeley)
"Phylogenetic Algebraic Geometry"





Conference attendees in front of a poster during the 2005 HMC Mathematics Conference on Scientific Computing.

Left to Right: Linda Petzold (UC Santa Barbara), Adrian Lew (Stanford University), Darryl Yong (HMC), Randy LeVeque (University of Washington), Jane Wang (Cornell University).

On November 5, 2005, the mathematics department hosted the seventh annual HMC Mathematics Conference on Scientific Computing. Plenary speakers discussed new developments in numerical analysis and techniques and how they have led to novel applications. The conference was organized by Professor Darryl Yong '96.

Randy LeVeque (University of Washington, Seattle)
"Finite-volume methods and software for hyperbolic PDEs and conservation laws"

Adrian Lew (Stanford University)
"Modeling and simulation of highly deformable materials"

Jane Wang (Cornell University)
"Computational modeling of insect flight"

Linda Petzold (University of California, Santa Barbara)
"Bridging the scales in biochemical simulation"

These conferences were sponsored by the HMC Mathematics Department and the National Science Foundation, which provided travel funds for graduate students and recent doctorate recipients from around the country to attend. The 2005 conference was also organized in cooperation with the Society for Industrial and Applied Mathematics. Videos of the plenary talks from the 2005 conference can be viewed at

http://www.math.hmc.edu/baldyconf/2005/.

The upcoming 2006 conference on enumerative combinatorics will be held on October 7, 2006, and is being organized by Professor Arthur Benjamin. Details of the conference appear at

http://www.math.hmc.edu/baldyconf/.

One of the exciting aspects of the mathematics program at HMC is the array of wonderful speakers who visit the campus. In addition to the many excellent speakers who present in our Claremont Colleges Colloquium Series, we have several other venues for visiting speakers. For instance, each year the department hosts two to four special evening lectures that are designed to be fun and of interest to the entire HMC community. Over the last two years, these speakers have included Joe Gallian (University of Minnesota at Duluth) who spoke on "Breaking Driver's License Codes," Frank Morgan (Williams College) who spoke on "The Double Bubble Conjecture," Lew Lefton (Georgia Institute of Technology) who spoke on "Infinity Bottles of Beer on the Wall: What's so FUNNY about Mathematics," and Jorge Cham (California Institute of Technology) who spoke on "The Power of Procrastination." Jorge is the author of the web comic *Piled Higher and Deeper.* (A sample comic appears on the inside back cover.)

Additional talks included lunchtime research talks by Robin Thomas (Georgia Tech), Robert Hardt (Rice) and Aaron Fogelson (Utah). These speakers also used the opportunity to give an overview of their respective graduate programs. Finally, in April 2006 we had a special presentation by Peter Sarnak (Princeton University) who spoke on "Prime Numbers and Sieving." Sarnak is a renowned number theorist and was a featured guest on an episode of "Nova" about Fermat's Last Theorem (now called the Wiles' Theorem).

Lew Lefton (Georgia Institute of Technology) entertained and informed us with his talk "Infinity Bottles of Beer on the Wall: What's so FUNNY about Mathematics?" on April 7, 2006. (Photo by Lee Jones) Sample funny moment: "On my qualifying exam, I was shown two groups and asked if they were isomorphic. I thought it was a trick question, so I said, 'The first one is, but the second one isn't.'"

2004–05 Mathematics Colloquia

Surreal Factorization
Shahriar Shahriari (POM)

Quit Work, Play Poker, Sleep 'till Noon
Steve Bleiler (Portland State University)

Computational Paths to Mathematical Discovery
David Bailey (Lawrence Berkeley Labs)

Mathematical Aspects of Phylogenetic Trees
Francis Su (HMC)

Residue Class Fields of Rings of Real Analytic and Real Entire Functions
Mel Henriksen (HMC)

New Challenges for Applied Mathematics: From Image Processing to Robotic Swarms
Andrea Bertozzi (UCLA)

Placing Points in Polygons
Randy Maddox (Pepperdine University)

Highlights of Mathematics in Astronomy and Art
Helmer Aslaksen (National University of Singapore)

The Many Faces of Pi
Marc Chamberland (Grinnell College)

Eigenvalues of Random Matrices
Estelle Basor (Cal Poly, SLO)

Why Historical Truth Matters to Mathematicians: Dispelling Myths While Promoting Mathematics
Judy Grabiner (PIT)

Zoo of L-Functions: Infinities of Primes, Fermat's Last Theorem & Beyond
Ben Brubaker (Stanford University)

Modeling Ecological Complexity: Challenges and Opportunities
Larry Li (UC Riverside)

Braids, Graphs and Robots
Aaron Abrams (University of Georgia)

2-Groups: An Introduction to Higher-Dimensional Groups
Alissa Crans (Loyola Marymount)

Combinatorial Geometric Flows
Ben Chow (UCSD)

Mathematical Visualization—More Than Just Pretty Pictures!
Richard Palais (UC Irvine)

The Four-Color Theorem
Robin Thomas (Georgia Tech)

Stability of Dpp Gradients and Drosophilia Wing Disc Formation
Fred Wan (UC Irvine)

Classifying Division Algebras
Ulrica Wilson (CMC)

Mathematics of Splashing and Water Entry
Sam Howison (Oxford)

Ambiguity in Visualizing Possible Universes
Dave Bachman (PIT)

The Making of the 2003 Math Awareness Month Poster
Joe Gallian (University of Minnesota Duluth)

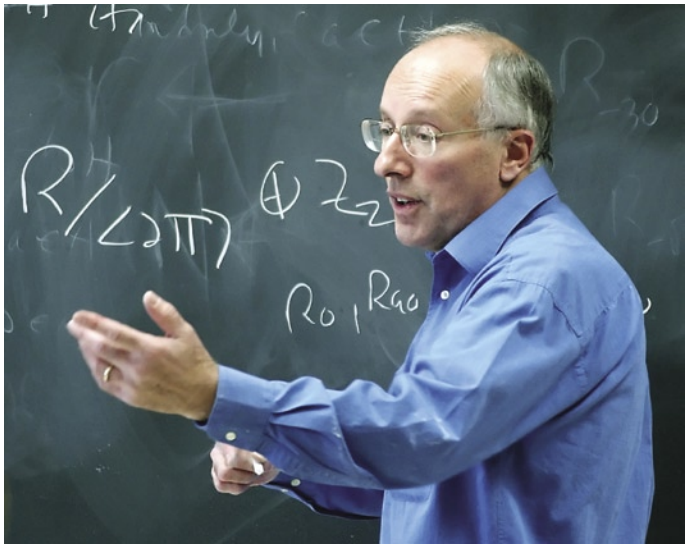
Electric Sheep and Landscape Dynamics
Ralph Abraham (UCSD)

Eigenvalues of Random Matrices over Finite Fields
Kent Morrison (Cal Poly SLO)
Optimal Contol of Immunotherapy and Chemotherapy of Tumors
Weiqing Gu (HMC)

2005–06 Mathematics Colloquia

Lissajous Knots
Jim Hoste (PIT)
Commutativity Conditions for Rings, 1950–2005
Jim Pinter-Lucke (CMC)
A Combinatorial Proof of Vandermonde's Determinant (and other sabbatical adventures)
Art Benjamin (HMC)
The Geometry, Nonlinear Dynamics and Physics of Combinatorial Games: A Renormalization Approach
Adam Landsberg (Joint Sciences, Claremont)
Mirror Symmetry and the Mirror Principle
Emrah Paksoy (POM)
Posets, Tableaux and Dominos
Kendra Killpatrick (Pepperdine University)
Linking Numbers
Brian Munson (Stanford University)
Reduction of Discontinuity for Derivations on Fréchet Algebras
Marc Thomas (Cal State Bakersfield)
Modeling and Simulation of Microstructures and Biostructures
John Lowengrub (UC Irvine)
Computing the Shape of a Space
Afra Zomorodian (Stanford University)
The Linear Algebra of Internet Search Algorithms
Lesley Ward (HMC)
Bridging the Scales in Biochemical Simulation
Linda Petzold (UC Santa Barbara)
Geometric Structures on Three-Dimensional Shapes
Michael Krebs (Cal State LA)
Hyperconvexity and Metric Trees
Asuman Aksoy (Claremont McKenna)
Shape, or The Blind Mathematicians of Hindustan
Kathryn Leonard (Caltech)
A Mathematician's Look at Blood Clotting
Aaron Fogelson (University of Utah)
Gröbner Bases with Valuations
Ed Mosteig (Loyola Marymount University)
On the Interaction of Nearly Parallel Vortex Filaments
Gustavo Ponce (UC Santa Barbara)
Intrinsically Linked and Knotted Graphs
Blake Mellor (Loyola Marymount University)
Stochastic Modeling of Cancer
Natalia Komarova (UC Irvine)
Hamming it up: Information and Coding Theory and You
Sarah Fogal (Caltech)
Towards Pluggable, Optional Type Systems in a Programming Language
Art Lee (CMC)
Mathematics of Black Holes: Geometry Meets Astronomy
Emrah Paksoy (POM)
Descartes' Attempt to Base the Certainty of Algebra on Mental Vision
Henk Bos (Mathematisch Instituut Universiteit Utrecht)
Point-Clouds, Witnesses and Blind Robots or What Happens When a Computer Learns Topology
Vin de Silva (POM)
Increasing the Number of Mathematics Majors
William Yslas Velez (University of Arizona)
Ranks of Elliptic Curves
Karl Rubin (UC Irvine)
A Motivated Introduction to Modular Forms
Nathan Ryan (UCLA)

Frank Morgan (Williams College) creating a bubble within a bubble during his talk "Double Bubble Conjecture" on April 27, 2004.



Joe Gallian (University of Minnesota at Duluth) gave an entertaining talk entitled "Breaking Driver's License Codes" on April 7, 2005. He discussed his adventures in uncovering the algorithms that different states use to assign driver's license numbers.

WHAT'S NEW?

WE would like to HEAR from YOU!

Please drop us a line to tell us what you're up to. We are especially interested in news suitable for sharing in the "Alumni News" section of forthcoming issues of **Mudd**math.

Name

Year of Graduation E-mail

Permission to share your information in the **Mudd**math Newsletter—please sign and date

Current job title and employer

Professional and/or personal news:

☐ I would like to order an HMC Mathematics Absolute Value T-Shirt. (Please see facing page.)

Size: S M L XL

I have enclosed a check for _____ ($20 each shirt).

Please return this form to:

MUDDmath **Editor, Department of Mathematics**

Harvey Mudd College, 301 Platt Boulevard, Claremont, CA 91711

MUDD MATH

$$\lim_{x\to a} f(x) = L \Leftrightarrow (\forall \epsilon > 0)(\exists \delta > 0)(\text{if } 0 < |x-a| < \delta \text{then} |f(x)-L| < \epsilon) \bullet \lim_{n\to\infty}\left(1+\frac{1}{n}\right)^n = e \bullet e^{i\pi} = -1 \bullet f'(a) = \lim_{h\to 0}[f(a+h) - f(a)]/h \bullet (fg)'(x) = f'(x)g(x)+f(x)g'(x)$$

$$)-(fg')(x)]/g^2(x) \bullet (f\circ g)_{\cdot}$$

$$\cdot)(x-a) \bullet \int_a^b f(x)dx = \lim_{||\mathcal{P}||\to 0} \sum_{\cdot}$$

$$_{\cdot}f = f(x) \bullet \int_a^b f(x)dx = F(b)-F(a) \bullet A = \frac{1}{2}\int_{\alpha}$$

$$_a \sqrt{1+f'(x)^2}dx \bullet S = 2\pi\int_a^b f(x)\sqrt{1+f'(x)^2}dx \bullet$$

$$f(x)^2dx \bullet \ln x = \int_1^x \frac{1}{t}dt \bullet (e^x)' = e^x \bullet uv = \int uv'dx + \int vu'_{\cdot}$$

$$\cdot \frac{\sin x}{x}dx = \frac{\pi}{2} \bullet f(x) = f(a)+f'(a)(x-a)+\cdots+\frac{f^{(n)}(a)}{k!}(x-a)^{n}$$

$$\frac{^{n+1)}(c)}{(n+1)!}(x-a)^{n+1} \bullet e^x = 1+x+\frac{1}{2!}x^2+\frac{1}{3!}x^3+\cdots+\frac{1}{n!}x^n+\cdots \bullet \ln 2 =$$

$$-\frac{1}{2}+\frac{1}{3}-\frac{1}{4}+\cdots \bullet (1+x)^s = \sum_{k=0}^{\infty}\binom{s}{k}x^k \bullet (u\times v)' =$$

$$u'\times v + u\times v' \bullet s(t) = \int_a^t ||r'(u)||du \bullet \kappa = \frac{|r'\times r''|}{|r'|^3} \bullet \tau =$$

$$\frac{r'\times r''\cdot r'''}{|r'\times r''|^2} \bullet \frac{dT}{ds} = \kappa N \bullet \frac{dB}{ds} = \tau N \bullet \frac{dN}{ds} = -\kappa T - \tau B \bullet D(f\circ g) =$$

$$Df\circ gDg \bullet f'(r(t)) = \nabla f(r(t))\cdot r'(t) \bullet S = \iint_R |T_u(u,v)\times$$

$$T_v(u,v)|dA \bullet \iint_R \phi(x,y)dxdy = \iint_S \phi(f(u,v),g(u,v))\frac{\partial(f,g)}{\partial(u,v)}dudv \bullet$$

$$\oint_C Pdx+Qdy = \iint_R\left(\frac{\partial Q}{\partial x}-\frac{\partial P}{\partial y}\right)dA \bullet \nabla\cdot(\nabla\times F) = 0 \bullet \iint_S(\nabla\times$$

$$F)\cdot ndS = \int_{\partial S} F\cdot dr \bullet \iiint_V \nabla\cdot F dV = \iint_{\partial V} F\cdot ndS \bullet \int_{\partial D^+}\omega =$$

$$\int_{D^+} d\omega \bullet |a_1+a_2+\cdots+a_n| \le |a_1|+|a_2|+\cdots+|a_n| \bullet (Av,w) =$$

$$(v,A^*w) \bullet \det A = \sum_{\sigma\in S_n}(-1)^{\sigma}a_{1\sigma(1)}a_{2\sigma(2)}\cdots a_{n\sigma(n)} \bullet Av = \lambda v \bullet$$

$$A = C^{-1}TC \bullet \det A = 1/\det A^{-1} \bullet (AB)^* = B^*A^* \bullet r(A)+n(A) =$$

$$\dim A \bullet |(v,w)|^2 \le ||v||^2||w||^2 \bullet a\in G \Rightarrow o(a) \mid o(G) \bullet a\in G \Rightarrow$$

$$a^{o(G)} = e \bullet a^{\phi(n)} \equiv 1 \bmod n \bullet o(HK) = \frac{o(H)o(K)}{o(H\cap K)} \bullet o(G/N) =$$

$$o(G)/o(N) \bullet \Gamma(\nu) = \int_0^{\infty} e^{-t}t^{\nu-1}dt \bullet \Gamma(\nu+1) = \nu\Gamma(\nu) \bullet \frac{1}{2}[f(x+$$

$$0)+f(x-0)] = \frac{1}{2\pi}\int_{-\pi}^{\pi} f(\xi)d\xi + \frac{1}{\pi}\sum_{n=1}^{\infty}\int_{-\pi}^{\pi} f(\xi)\cos n(\xi-x)d\xi \bullet$$

$$f(x) = \frac{1}{\pi}\int_0^{\infty}\int_{-\infty}^{\infty} f(\xi)\cos[\alpha(\xi-x)]d\xi d\alpha \bullet \frac{1}{2}a_0^2+\sum_{n=1}^{\infty}(a_n^2+$$

$$b_n^2) = \frac{1}{\pi}\int_{-\pi}^{\pi} f^2(x)dx \bullet \rho^2y''+\rho y'+(\lambda^2\rho^2-\nu^2)y = 0 \bullet J_{\nu}(x) =$$

$$\sum_{j=0}^{\infty}\frac{(-)^j}{j!\Gamma(\nu+j+1)}\left(\frac{x}{2}\right)^{\nu+2j} \bullet (x^{-n}J_n(x))' = -x^{-n}J_{n+1}(x) \bullet J_n(x) =$$

$$\frac{1}{\pi}\int_0^{\pi}\cos(n\phi - x\sin\phi)d\phi \bullet (1-x^2)y''-2xy'+\lambda y = 0 \bullet P_n(x) =$$

$$\frac{1}{2^n}\sum_{j=0}^{m}\frac{(-)^j}{j!}\frac{(2n-2j)!}{(n-2j)!(n-j)!}x^{n-2j} \bullet z^n = r^n(\cos n\theta + i\sin n\theta) \bullet u_x =$$

$$v_y,\ u_y = -v_x \bullet \log z = \text{Log}r+i\theta \bullet f(z_0) = \frac{1}{2\pi i}\int_C \frac{f(z)}{z-z_0}dz \bullet 2\pi i f(z) =$$

$$\sum_{n=0}^{\infty}(z-z_0)^n\int_{C_1}\frac{f(z')dz'}{(z'-z_0)^{n+1}}+\sum_{n=0}^{\infty}\frac{1}{(z-z_0)^n}\int_{C_2}\frac{f(z')dz'}{(z'-z_0)^{1-n}} \bullet K_1+$$

$$\cdots+K_n = \frac{1}{2\pi i}\int_C f(z)dzs \bullet u(r,\theta) = \frac{1}{2\pi}\int_0^{2\pi}\frac{(r_0^2-r^2)u(r_0,\theta')}{r_0^2-2r_0r\cos(\theta'-\theta)+r^2}d\theta' \bullet$$

$$\pi^2/6 = 1+(1/2)^2+(1/3)^2+\cdots \bullet \pi = 2\frac{2}{1}\frac{2}{3}\frac{4}{3}\frac{4}{5}\frac{6}{5}\frac{6}{7}\cdots \bullet \pi =$$

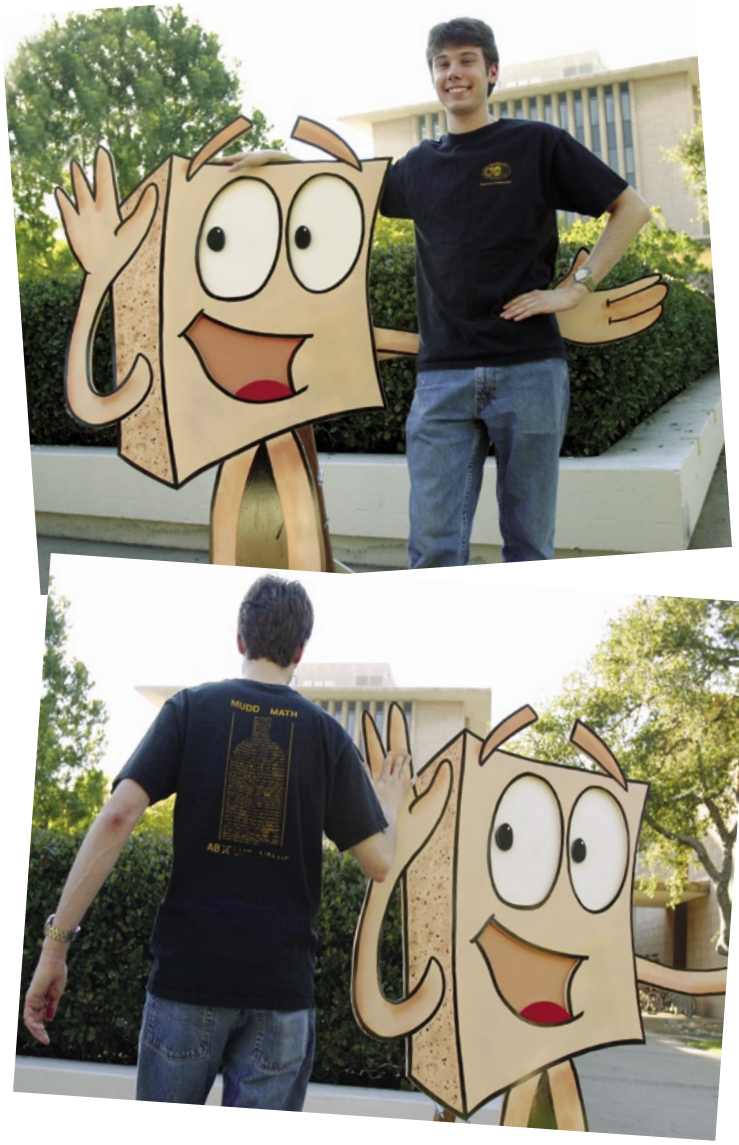
$$4(1-1/3+1/5-1/7+\cdots) \bullet \pi = 6(\frac{1}{2}+\frac{1}{2\cdot 3\cdot 2^3}+\frac{1\cdot 3}{2\cdot 4\cdot 5\cdot 2^5}+\cdots) \bullet \frac{\pi^2}{6} =$$

$$\frac{2^2}{2^2-1}\frac{3^2}{3^2-1}\frac{5^2}{5^2-1}\frac{7^2}{7^2-1}\cdots \bullet \det A = \sum_{\sigma\in S_n}(-1)^{\sigma}a_{1\sigma(1)}a_{2\sigma(2)}\cdots a_{n\sigma(n)} \bullet$$

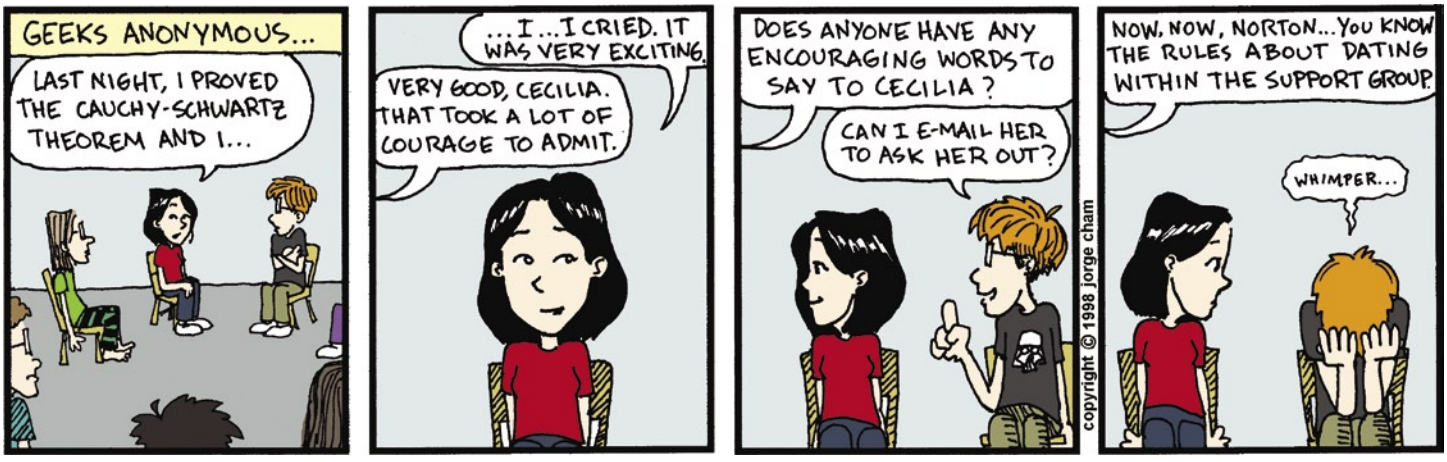
$$Av = \lambda v \bullet A = C^{-1}TC \bullet \det A = 1/\det A^{-1} \bullet (AB)^* = B^*A^* \bullet$$

$$|a_1+a_2+\cdots+a_n| \le |a_1|+|a_2|+\cdots+|a_n| \bullet |(v,w)|^2 \le ||v||^2||w||^2 \bullet$$

ABSOLUTE VALUE



ABSOLUTE VALUE—that's what Mudder math major Eric Malm '05 and his friend, Wally Mudd, think about the Math T-shirt as Eric models the front and back for Wally! Want one too? Order one using the form on the facing page.



Comic strip from Jorge Cham's book *Piled Higher and Deeper* (www.phdcomics.com), reprinted with permission. Jorge's presentation "The Power of Procrastination" was a big hit at HMC.

The Harvey Mudd College Eigenteam consisting of 2006 Summer Math students (class of '09) and instructors. Top row (left to right): Andrew La Motte-Mitchell, David Stachnik, Rishad Manekia, Judy Hines; middle row: Professor Michael Orrison (DJ Sürjectivə), Susan Willis, Christina Snyder, Professor Jon Jacobsen (Coach); bottom row: Lolly Simoni, Kevin Samrick, Glennis Rayermann.

Harvey Mudd College
Department of Mathematics
301 Platt Boulevard
Claremont, CA 91711

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