**The Power of Connections**

Diverse networks stimulate research and learning
The Power of Connections

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Coming Attraction
Saying goodbye is hard. I’ve been having to do it since January, when I announced my decision to leave Princeton and take on the presidency of Harvey Mudd College. But in these last few months, I also have witnessed the greatest affirmation of the hard work we have done together over the last three years. The faculty, staff and students; the senior University administration; the trustees; the alumni—all are committed to the strategic vision we created for the School of Engineering and Applied Science. And the choice of H. Vincent Poor ’77, announced on the next page, as my successor doubles that momentum. We could not ask for a more thrilling step forward. When I asked Vince to become the founding director of the Center for Innovation in Engineering Education last year, he jumped into action and began producing results. He will do the same as dean.

Looking back over these last years and all our work and fun together, the result that makes me proudest is the vision for Princeton Engineering. We created it together—800 people in a year of intensive work, rich discussions and eye-opening ideas. It’s a vision that makes great sense for Princeton. We called it “Engineering for a Better World” because it dedicates us to serving society and educating leaders. It is appropriate that this issue of EQuad News emphasizes the “Power of Connections” because our plan calls on us to build on our already substantial connections to the broader University with its deep strengths in the natural and social sciences, public policy, architecture and humanities. We are, more than ever, conducting research that crosses the conventional boundaries between disciplines, allowing us to tackle real-world problems in all their complexity. These connections also help us transform engineering education and teach the kind of innovation and leadership that are crucial in today’s world.

It’s also a vision that makes great sense to me personally. In moving to Mudd—a science and engineering college that takes great pride in its connections to the liberal arts community in the Claremont College system—I am excited about furthering the mission that many of us share to harness the power of technology to make a positive difference.
Vincent Poor ’77, distinguished teacher-scholar, to become engineering dean

Maria Klawe resigns to assume presidency of Harvey Mudd College

H. Vincent Poor, a Princeton alumnus and professor of electrical engineering known worldwide as a distinguished researcher, teacher and innovator, has been named dean of the University’s School of Engineering and Applied Science, effective June 1.

Poor will succeed Maria Klawe, who announced in January that she will leave Princeton to become president of Harvey Mudd College in California. Klawe led the engineering school through an important strategic planning effort and into a period of major growth.

“Vince Poor exemplifies all the qualities we seek in a Princeton professor: He combines world-class scholarship with a true dedication and gift for teaching,” said President Shirley M. Tilghman. “Both of these qualities—along with his great personal warmth—will serve him and Princeton well as the engineering school moves ahead with its very exciting vision for engineering research and education.”

“I am thrilled to be taking on this role and am honored that my colleagues and the University administration have entrusted it to me,” said Poor. “The engineering school is on the threshold of great things. Maria’s leadership in creating a vision for the school—and the way that the faculty rallied around that vision—set the groundwork for taking the school to a new, even higher level.”

“We’re moving full-speed ahead,” he added.

Poor earned bachelor’s and master’s degrees in electrical engineering from Auburn University, and completed a Ph.D. in electrical engineering and computer science at Princeton in 1977. Currently the Michael Henry Strater University Professor of Electrical Engineering, he joined the Princeton faculty in 1990 after 13 years at the University of Illinois at Urbana-Champaign. He has also held visiting positions at a number of other institutions, including Imperial College (London), Harvard and Stanford.

In 2005, Klawe appointed Poor to be the founding director of the Center for Innovation in Engineering Education, an initiative to prepare all students—both engineers and non-engineers—to be leaders in an increasingly technology-driven society. As center director, he led a group of 10 faculty members from seven departments in creating an alternative freshman engineering curriculum that integrates math, physics and hands-on engineering projects into a unified course series.

Through the center and his own teaching, Poor also has emphasized the need to engage non-engineering students in courses that examine technological issues that shape and are shaped by society. In 2000, he created a course called “The Wireless Revolution,” which explores the technical, social and economic dimensions of wireless communications. The course quickly became one of the most popular on campus with enrollments of more than 200 students.

The National Science Foundation recognized Poor’s contributions in 2002, presenting him with the Director’s Award for Distinguished Teaching Scholars, the foundation’s highest honor for excellence in both teaching and research. He received the engineering school’s Distinguished Teaching Award in 2003 and the Institute of Electrical and Electronics Engineers (IEEE) Education Medal in 2005.

Poor also has maintained a very active research program. In 2005, he published a book, 25 journal articles and 26 conference papers. He supervised nine graduate students and six postdoctoral researchers working on 10 separately funded projects. He received two patents and served as editor-in-chief of a leading journal, the IEEE Transactions on Information Theory.

An elected member of the National Academy of Engineering and a fellow of the IEEE, Poor is an authority on wireless communications and signal processing. His graduate-level textbook, “An Introduction to Signal Detection and Estimation,” is considered the definitive reference in its field. He is also a fellow of the American Academy of Arts and Sciences, and a recent Guggenheim fellow.

Poor said that, as dean, a top priority will be to build on the core elements of the school’s strategic vision: setting a new standard for engineering education with an emphasis on innovation and leadership; and conducting cross-disciplinary research that has a major impact on national and global problems.

Poor said he wants the school to leverage its already significant collaborations with the broader University in areas including biological engineering, neuroscience, environmental science, materials science, information tech-
nology policy, finance, architecture and music. “This is happening already, but we want to make these collaborations as easy as we can,” he said.

“At the same time, we must maintain our emphasis on fundamental research, which has been the hallmark of Princeton Engineering,” Poor said.

It also is critical for the school to build its relations with industry and government, both to provide a real-world context for education and to maximize the impact of Princeton research in solving problems and creating opportunities, Poor said. His own experience has included consulting relationships with more than a dozen corporations and government labs.

Tilghman’s decision to appoint Poor followed three months of intensive work by a nine-member search committee chaired by Sharad Malik, the George Van Ness Lothrop Professor in Engineering. The other members were: Bonnie Bassler, professor of molecular biology; William Bialek, the John Archibald Wheeler/Battelle Professor in Physics; Claire Gmachl, associate professor of electrical engineering; Jeremy Kasdin, associate professor of mechanical and aerospace engineering; Richard Register, professor of chemical engineering; Jennifer Rexford, professor of computer science; James Smith, professor of civil and environmental engineering; and Robert Vanderbei, professor and chair of operations research and financial engineering.

The committee met with about 100 faculty members, students and administrators, both from within and outside Princeton, and defined three main qualities it was seeking: strong leadership, scholarship and teaching.

“Vince clearly excels in all these qualities, and he has a great openness and willingness to listen,” Malik said. “Maria has done a wonderful job uniting the school behind the strategic vision, and Vince has the combination of skills that will maximize this momentum.”

Klue announced her decision Jan. 17 to step down as dean and accept the presidency of Harvey Mudd, a liberal arts college focusing on engineering, science and mathematics. Mudd was founded in 1955 as one of The Claremont Colleges in Claremont, Calif.

Tilghman praised Klue for her record of accomplishments since she came to Princeton in January 2003. “We are very grateful to Maria for her leadership of the School of Engineering, and especially for creating and coordinating a strategic planning process that produced an exciting vision for the future of engineering at Princeton,” Tilghman said. The strength of that plan and its support among faculty members led Tilghman to ask the search committee to consider candidates who “have a thorough understanding of and commitment to the school’s strategic plan.”

In announcing her decision to leave, Klue told faculty, students and staff, “This has been one of the most difficult decisions of my career, and one that I bring to you with mixed emotions. I am thrilled to be taking the leadership of a college that has been a pioneer and innovator in the teaching of science and engineering over the last 50 years. I also am very sad to leave Princeton where I have had the privilege of working with an incredibly talented, energetic and supportive group of people.”

Klue praised the selection of Poor as her successor. “I’m truly thrilled for Princeton Engineering, and for Vince himself, that Vince Poor will be our next dean,” Klue said.

“Vince is an amazing teacher, a phenomenal scholar and a wonderful person. Over the past year he has demonstrated superb leadership skills as the founding director of the Center for Innovation in Engineering Education and in the creation of the integrated Engineering Math Physics curriculum for first-year students. He will do a fantastic job of making our strategic vision a reality.” – SS

Fighting sound with sound, new modeling technique could quiet aircraft

Newly published research by a Princeton engineer suggests that understanding how air travels across the sunroof of a car may one day make jet engines less noisy.

Clarence Rowley ’95, an assistant professor of mechanical and aerospace engineering, did not actually conduct his experiments on a sunroof. Rather, he and collaborators used computer simulations and subsonic wind tunnels at Princeton and at the U.S. Air Force Academy in Colorado Springs, to experiment with models that resembled the open sunroof of a speeding car.

Rowley showed that his simulations could predict how sunroof airflow would behave under various conditions. Just as important,
Fueling a start-up company

When they met as freshmen, Nate Lowery and Sebastien Douville, both mechanical and aerospace engineering majors, soon discovered they shared an interest in alternative energies. But they never dreamed that by the time they were seniors they would not only have invented a new way to produce an alternative fuel but also would be launching a company based on their idea.

Douville and Lowery have invented a more efficient way to produce biodiesel, a plant-based fuel that has been around since the 19th century but was eclipsed by oil around the turn of the century.

Now biodiesel is back, with the federal government instituting tax incentives last year to spur innovation and development. Biodiesel produces less soot and less greenhouse gas than oil-based diesel, and it can be produced domestically from renewable resources.

“We’re hitting this at a time when the field is exploding,” said Lowery.

Lowery and Douville’s invention is the basis of both their senior independent work and their company, Axios Energy LLC.

Cavity Flow Simulations

Under normal circumstances
Faster air shears away from slower moving air, flapping up and down like a flag in the wind.

When the layer of air hits the edge, it creates an acoustic wave, otherwise known as noise.

With Rowley/Williams control system

1 This microphone monitors the flapping and feeds information to the controller.
2 The controller makes predictions based on Rowley’s mathematical model and sends signals to the speaker.
3 The speaker produces opposing acoustic waves that neutralize the ones produced by the airflow.

The result is dramatically smoother airflow.

This research may ultimately lead to modifications of jet engines to make them quieter as they fly over neighborhoods. The research also has important military applications. For example, it would enable stealth aircraft to fly faster because it would reduce buffeting when doors of a weapons bay are open. And Rowley is currently using insights garnered from this work to help develop ultrasmall, unmanned aircraft that would be useful for surveillance or search-and-rescue missions.

Rowley’s task was not an easy one. To precisely model the air current would have required solving more than 2 million equations. Solving these equations by themselves is not too great a challenge for today’s computers, but manipulating them to figure out how to make the air flow quieter would require far more calculation.

“Basically, it would have been computationally impossible,” Rowley said.

So he took an unusual approach. He selectively picked mathematical tools from three different disciplines—dynamical systems, control theory and fluid mechanics—and yoked them together to come up with a computer simulation that, by solving only four equations, could approximate almost identically the answer to the problem that normally would have taken 2 million equations to figure out.

Once he figured out the model, Rowley fought sound with sound.

Rowley focused on the layer of air just above his simulated sunroof, where faster moving air shears away from slower moving air. “This shear layer flaps up and down like a flag in the wind,” Rowley said.

Each time this layer of air flaps down and hits the leading edge of the sunroof, it makes what scientists call an acoustic wave (most people just call this noise).

In his computer model and in wind-tunnel experiments with collaborator David Williams of the Illinois Institute of Technology, Rowley placed a speaker at the front end of his sunroof and a microphone at the rear of the roof. The microphone monitored the flapping and fed this information to a controller. The controller, relying on predictions from Rowley’s model, then sent an opposing signal to the speaker, which is not much different from one found on a typical stereo.

“The physical mechanism is actually very simple,” Rowley said. “When the flag wants to push up we pull it down; when it wants to pull up we push it down. This is what makes it quiet.”

The same principles can be applied to quiet a jet engine or silence the open bays of a military craft. Rowley does not have immediate plans to promote the technique to the automotive industry to make quieter sunroofs, but he is applying the knowledge to a new project involving tiny unmanned airplanes.

As part of a joint research project led by Caltech, Rowley is performing computational modeling, as well as building a controller, for aircraft that are the size of a typical model airplane. One day, the researchers hope, these aircraft will be able to fly with the speed of a bird and maneuver themselves with the three-dimensional agility of an insect.

This work was funded by the U.S. Air Force Office of Scientific Research. —TR
The seniors are currently making their biodiesel from 100 percent soybean oil, converting it to combustible fuel through a chemical process that involves mixing it with alcohol.

Biodiesel can be substituted easily for oil-derived diesel, the two seniors said.

“What makes this so exciting is that it is not a disruptive technology,” said Lowery. “The infrastructure is already there. It has the same performance standards as regular diesel but it is a much cleaner fuel.”

With the help of John Ritter at the University’s Office of Technology Licensing, Lowery and Douville have filed for a provisional patent. The two praised Ritter for his support and also gave enormous credit to their adviser, assistant professor Craig Arnold. “He is the most amazing professor,” said Lowery. “He has been supportive at every turn.”

Arnold said that the project has been student-driven since the beginning. The two came to him at the end of the last school year to talk about senior project ideas. They professed a general interest in an energy-related topic that would be environmentally responsible and might benefit people around the world.

Out of several ideas, the pair found biodiesel production the most captivating. “They really ran with the idea,” said Arnold. “They did a huge amount of research, not only in engineering, but also on the business side.” Arnold also underwrote their expenses to attend a biodiesel conference in California where Douville and Lowery furthered their knowledge while making important contacts in industry and finance.

While manufacturing biodiesel involves a lot of chemistry, the important challenges behind producing it economically involve many concepts from mechanical engineering such as fluid mechanics and materials science, Arnold said. “It is a very nice project from a mechanical engineering perspective. They are actually using the knowledge they acquired over the past four years and applying it.”

Lowery said that he and Douville have invented a new way to mix the ingredients that go into making biodiesel. “The constituents for making biodiesel are like oil and water—they don’t like to mix naturally,” he said.

By this spring, the partners said they were in the process of securing $1.5 million in funding for Axios Energy. In a second step, they hope to raise $30 million more to open a manufacturing plant in the New York/New Jersey port area that they say would be one of the five largest in the country. “One of the venture capitalists who read their business plan told me it was one of the best he had ever seen,” said Arnold.

Arnold said that the seniors were doing real-life engineering, which involves science, business and engineering. “They are using all of those skills. But I have been encouraging them to focus on the science for now. You can’t submit a business plan for your senior thesis,” he said.

Douville said that he equivocated about taking the risk of starting a new company and was thinking about taking a day job to give him financial security while he worked on the side to develop the business. In December he was offered a job after graduation working for a consulting firm and was planning to accept. But then he went to the final lecture in Ed Zschau’s course “High-Tech Entrepreneurship.” “It was an incredibly inspiring speech,” Douville said. “I called the consulting company that afternoon and told them I didn’t want the job. Even if we go down in flames, this will be the best experience of my life.”

Arnold cautions that any entrepreneurial venture is risky. “There are no slam-dunks,” he said. On the other hand, he said, “If it is possible to do it, these guys will make it happen.” —TR

From Quonset huts to dancers: Princeton engineers solve a nanotech mystery

Princeton researchers have untangled the mystery behind a puzzling phenomenon first observed more than a decade ago in the ultra-small world of nanotechnology.

Why is it, researchers wondered, that tiny aggregates of soap molecules, known as surfactant micelles, congregate as long, low arches resembling Quonset huts once they are placed on a graphite surface?

To fellow scientists and engineers, this question and the researchers’ answer is tantalizing since the discovery gives insight into “guided self-assembly,” an important technique in nanotechnology where molecules arrange themselves spontaneously into certain structures. It also may lead one day to valuable technological applications such as the creation of anti-corrosion coatings for metals and biomedical applications involving plaque formation with proteins.
In a paper appearing in the Jan. 13 issue of Physical Review Letters, a premier physics journal, Dudley Saville, Ilhan Aksay, Roberto Car and their colleagues explain how they unraveled the mystery. Saville and Aksay are members of the chemical engineering faculty, and Car is a professor of chemistry and the Princeton Institute for the Science and Technology of Materials.

The scientists discovered they and others had been operating on the flawed assumption that—in response to the texture of the graphite beneath them—surfactant molecules assembled themselves into Quonset hut shapes that stayed put.

Using atomic force microscope imaging by research associate Hannes Schniepp, the Princeton scientists were able to see that the micelle structures were not static but, rather, constantly on the move, building and rebuilding themselves into the same structures.

The researchers began to think of the images under their microscopes not as Quonset huts, but dancers.

“We spent a year trying to describe why these rods orient themselves on the graphite surface,” Saville said. “But it turns out that we had imaged the dancers in freeze-frame. What we did not take into account in our original thinking was that micelles on the surface are in constant rotary motion.”

Under most conditions, small particles make tiny random movements known as Brownian motion. Powered by Brownian motion, a single surfactant can be thought of as a dancer spinning about on her own; it is impossible to predict the precise pattern of movement.

The researchers discovered that, when assembled on a graphite “stage,” the micelle dancers no longer moved randomly, but fell into a choreographed pattern of movement.

What was overriding the Brownian motion?

The answer turned out to be a phenomenon known as van der Waals forces, which are weak interactions between molecules caused by slight imbalances of electric charges. The van der Waals forces are just strong enough to overcome the random Brownian motion and twist each micelle into a specific orientation.

Basic work by research associates Je-Luen Li and Jaehun Chun provided a description of the angular variation of the van der Waals interaction, and this enabled the group to cinch their argument.

“Saville and his coauthors combined theory at the surfactant and micellar scales with a series of careful experiments to resolve the dilemma,” said William Russel, the Arthur W. Marks ’19 professor of chemical engineering and the dean of the Graduate School, whose expertise includes small particle interactions and self assembly. “Long-range van der Waals forces, which are orientation-dependent, exert a torque on the entire micelle that is strong enough to overcome the randomizing tendency of Brownian motion.”

The scientists said their work opens new horizons to explore. “You need a critical number of dancers for this to happen, but we have no idea how many,” Aksay said. Moreover, he noted, the researchers can move on to other interesting questions, now that they know that the micelles are dynamic and understand the time frame in which they move. “This opens up the prospect for even more rigorous thinking.”

The research was funded in part by the National Aeronautics and Space Administration through the University Research, Engineering and Technology Institute on Biologically Inspired Materials and by the National Science Foundation through the Princeton Center for Complex Materials.

Top mathematicians gather to honor Princeton’s Erhan Çinlar

Nearly 100 leading mathematicians specializing in probability gathered in Princeton March 22 to honor Prof. Erhan Çinlar on his 65th birthday.

Those attending Çinlar’s Day, and the three-day Seminar on Stochastic Processes that followed it, constituted a veritable Who’s Who of probability research.

“The most amazing thing about this conference was the breadth and depth of the people who came,” said Robert Vanderbei, chairman of the Department of Operations Research and Financial Engineering. “It says a lot about Erhan. It’s always been one of Erhan’s great traits—being able to identify the right people to hang out with.”

Çinlar, the Norman Sollenberger Professor in Operations Research and Financial Engineering, said he was honored to have so many distinguished experts in the field of probability attend the festivities. “What can I say?” he said. “I have exquisite taste in friends.”

Rene Carmona, Paul M. Wythes ’55 Professor of Engineering and Finance, organized the day, which featured speakers Chris Burdzy of Seattle, Hans Foellmer of Berlin, Ron Getoor of San Diego, Jean Jacod of Paris, Haya Kaspi of Haifa and John Walsh of Vancouver.

Çinlar’s Day ended with a packed reception in the Friend Center and then dinner at Prospect House. “We wanted it to be a roast but,
Students build instant messaging system—instantly

Nineteen high school students from Trenton and Lawrence arrived on the Princeton campus Jan. 26 with a mission: to assemble cutting-edge optics devices under a tight deadline so that by the end of the day they could instant message each other using computers connected by nothing more than two beams of light.

The students worked in the EQuad's electrical engineering teaching lab as part of Materials Science Day, an event sponsored by the Princeton Institute for the Science and Technology of Materials and the Princeton Center for Complex Materials.

The day was an abridged version of a lab session that Dan Wasserman, a postdoctoral fellow, and Claire Gmachl, associate professor of electrical engineering, used last semester in “Hands-on Optical Engineering,” an innovative course in optics that they developed for Princeton students not majoring in science or engineering.

“There is not that much of a knowledge gap between a non-science Princeton student and a high school student who is interested in science,” said Wasserman. “The main challenge was time.” The high school students had to squeeze four weeks of college-course material into less than six hours.

The students had to build software using a visual programming language called Labview and then assemble a circuit board. After much testing and troubleshooting, they were able to send typed messages from one computer to another wirelessly, with the help of devices that transmitted and received pulses of light emitted from a laser diode. The technology is similar to that used in fiber-optic cables except that the light signals are transmitted through the air rather than through cables.

After he built his software, Nyle Ross, a sophomore at Lawrence High School, watched an oscilloscope visually translate the letters of his first name into the 0s and 1s of computer language as he typed them into the computer keyboard.

“Pretty cool,” observed Noel Powell, a classmate of Ross’ at Lawrence.

Erik Gonzalez, Michael Davila and Leeshua Pica, all of Trenton Central High School, built their circuit board as a team. When they were done Pica typed a test message in pink (to match her pink shirt and pink sequined slippers): “Hello!!:)”, she wrote. “Michael’s taller than Leeshua and Erik wants 2 b famous.”

The students were guided in their efforts by volunteers from MentorPower, a program that serves economically disadvantaged students. Also assisting the students were Princeton graduate students Anthony Hoffman, Afusat Dirisu, Guillaume Sabouret, Fatima Toor and Weiwei Zheng and postgraduate fellow Sylvia Smullin.

“It’s invaluable for these kids to see the science behind the technology that they use you know, we’re engineers,” said Vanderbei. “So it was more tributes than roasts.”

Special dinner guests included Vice Provost Kathy Rohrle; professors of mathematics Joseph Kohn, Edward Nelson and Yakov Sinai; the mathematician John Nash; and H. Vincent Poor ‘77, the incoming dean of engineering.

Çinlar was honored for his contributions to the theory of Markov Processes, an important feature of the mathematical study of probability.

One of Çinlar’s most professional contributions was to help create the annual Seminar on Stochastic Processes. The 2006 seminar, which followed Çinlar’s Day, was held at Princeton.

The seminar is now an institution in the probability community. Established in 1981 by Çinlar, K.L. Chung and R.K. Getoor, the seminar gives researchers a forum to exchange ideas and establish collaborations.

“Only five speakers are invited every year, so to be invited is a great honor,” said Carmona. This year the speakers were Eulalia Nualart, of the University of Paris; Walter Schachermayer, of the Technical University of Vienna; Amir Dembo, of Stanford University; Frank den Hollander, of Leiden University; and Steve Evans, of the University of California-Berkeley.

In 1999, Çinlar also helped create the Engineering School’s Department of Operations Research and Financial Engineering at Princeton, the first department of its kind in the world.

“Creating this department was a very bold, visionary move on the part of the administration,” said Carmona. The department focuses on engineering for business, commerce, and industry, and students in ORFE are typically engineering innovators and entrepreneurs.

Çinlar was the first chairman of the department. “I want to be a father like he was a chairman,” said Carmona. “He made every single one of us think we were special. That is how he got people to do the best job they could possibly do.” —TR
Erik VanMarcke, a professor of civil and environmental engineering, has received a $3 million grant to start a center for risk analysis. “The idea is to develop improved methods for estimating damages and losses during extreme events like the recent Rita and Katrina hurricanes,” said VanMarcke.

The grant covers three years of funding. It is from the Associated Electric and Gas Utilities Insurance Services (AEGIS), a consortium of gas companies. VanMarcke said the center will focus on developing tools to better predict how often catastrophic events like earthquakes and hurricanes will occur, how big they will be, and what their impact will be on different types of structures.

“As we will be trying to quantify uncertainties—to get better estimations of probability distributions of losses,” said VanMarcke, who is affiliated with the Bendheim Center for Finance. “We are trying to translate physical damage into financial loss.”

VanMarcke said that the center would initially focus on risk quantification of extreme natural events but that it may also be potentially interested in risks like terrorism.

As a result, Connelly said, relationships with universities are becoming ever more crucial for industry.

The conference was organized by James Sturm, director of PRISM, and Richard Register, director of PCCM.

Researchers elaborated on their recent breakthroughs in fuel cells, flexible display panels, nanotechnology for drug delivery and many other areas.

According to Joseph Montemarano, PRISM’s director of industrial liaison, the purpose of the symposium was to give “tangible examples of the promise and value of new research directions.”

A full list of presenters at the conference, which took place Feb. 2-3, can be found at http://prism.princeton.edu/symp_agenda.htm.

—TR

Industry-academia conference stresses value of university research

Princeton Engineering hosted a two-day symposium in February that brought together researchers in photonics and materials science with venture capitalists and leaders in industry.

In his keynote address, Thomas Connelly ’74, senior vice president and chief science and technology officer of DuPont, noted that industry is increasingly relying on collaborations with university researchers like those at the Princeton Institute for the Science and Technology of Materials (PRISM) and at the Princeton Center for Complex Materials (PCCM).

“The days of building big laboratories and bringing in all the people you need are over,” said Connelly, who earned bachelor’s degrees from Princeton in both chemical engineering and economics. “That is an outdated model.”

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Patents from Princeton Engineering

New method makes optimal use of scarce radio spectrum

H. Vincent Poor ’77, the then incoming dean of engineering, recently received patent 6,968,022 for a novel solution to what is perhaps the most fundamental problem in wireless communications: scarce spectrum.

“Everybody and his brother is trying to solve this problem,” said Paul Henry, a member of the Access Technology & Applications Research Division at AT&T Labs.
Since space within the radio spectrum is an expensive commodity, wireless providers are interested in getting as much capacity as possible out of limited bandwidth.

Poor's technique is based on the use of multiple antenna beams to minimize interference among multiple users in wireless systems. Instead of assigning a given beam to each user, Poor's system would shuffle the beams among users, on the fly, depending upon usage.

“Our technique is to take a fixed number of such beams and try to find the optimal sequence in which to use them,” said Poor. This would greatly increase the number of people who could use a given slice of the radio spectrum at the same time.

“What Vince has pioneered is the divide-and-conquer approach,” said Henry.

Poor’s coinventor is Andrew Logothetis, a former post-doctoral student of his who is now working at Ericsson in Sweden.

Poor’s approach has one major drawback: it requires so much processing power that it would not be economical to implement in today’s hardware.

Henry of AT&T said he was optimistic about the future of Poor’s idea. He cited Moore’s Law, the observation attributed to Intel co-founder Gordon Moore that the number of transistors that can be squeezed onto a circuit board doubles every 18 months.

“It may not be economical now but if you believe in Moore’s law,” he said, “one day it will be.”

Poor also recently received patent 6,930,637 for a “method and apparatus for high-resolution tracking via mono-pulse beam-forming in a communication system” (assigned to Texas Instruments). You can find Poor’s patents online—as well as other recent patents granted to Princeton Engineering faculty (see below)—at www.uspto.gov.

• Sigurd Wagner, professor of electrical engineering, received patent 6,893,896 for a “method of making multilayer thin-film electronics.”
• Claire Gmachl, professor of electrical engineering, is co-inventor of patent 6,940,639 for “phase matched parametric light generation in monolithically integrated intersubband optical devices” (assigned to Lucent Technologies).
• Marc Baldo *01 and professor emeritus Stephen Forrest are co-inventors of patent 7,001,536 for “organometallic complexes as phosphorescent emitters in organic LEDs” and also, with Russell James Delmar Holmes, graduate student in EE, of patent 6,970,490 for “organic light emitting devices based on the formation of an electron-hole plasma.”
• Robert Prud’homme, professor of chemical engineering, is co-inventor of patent 6,936,454 for “compositions for fracturing subterranean formations.”
• Stephen Chou, professor of electrical engineering, and coinventors Allan Shih-Ping Chang *05, Hua Tan ’04, Wei Wu ’03 received patent 6,999,156 for a “tunable subwavelength resonant grating filter.” Chou also received patent 6,946,360 for an improved method of fluid pressure bonding (assigned to Nanonex Corporation).
• James Sturm ’79, professor of electrical engineering is a co-inventor of patent 6,881,317 granted to Lotien Huang *04 for “fractionation of macro-molecules using asymmetric pulsed field electrophoresis.”
• Jaswinder Singh, professor of computer science, and research staff member Randolph Wang received patent 6,915,294 for a “method and apparatus for searching network resources” (assigned to firstRain, Inc.).
• Kai Li, professor of computer science, received patent 7,007,141 for an archival data storage system and method (assigned to Data Domain).

Art of Science exhibit to open in May

The second annual Princeton University Art of Science exhibit will open May 10 with a reception in the Friend Center. The juried show will feature images, videos and sounds produced in the course of scientific or technical research. “Much of the work that we find so compelling may be likened to ‘found art,’” said Adam Finkelstein, associate professor of computer science. “Researchers create images or other artifacts in the pursuit of math, science and engineering, and often they turn out to be quite beautiful when viewed as works of art.

The question of whether this is serendipity, or perhaps the expression of some deeper connections between aesthetics, order, nature and complexity remains to be answered by the viewer.”

During its first two years, the competition has been open exclusively to the Princeton community. Next year the call for entries will be worldwide.

An online gallery of images from the competition will be available at www.princeton.edu/artofscience following the opening.

—TR
Faculty viewpoint
Chazelle: The greatest computer science revolution is yet to come

At the annual meeting of the American Association for the Advancement of Science in February, professor of computer science Bernard Chazelle issued a call to arms for his profession, challenging his colleagues to evangelize the importance of studying computer science. The following is adapted from a longer essay by Chazelle that appears in the April issue of Math Horizons titled “Could Your iPod Be Holding the Greatest Mystery in Modern Science?”
Computer science is not just about gaming, not just about the Internet; it offers an original window through which to view the world.

Computer science is full of mysteries, none more vexing than this one:

The top 36 computer science departments in the United States saw enrollments plummet 20 percent in the last five years. Why are students running away from the field at the very moment that the computer science revolution is just unfolding?

Most people think of computer science, if they think of it at all, as being something useless—the way that, say, people think of plumbing as being useful. And it is, obviously. But it is much more than that. Computer science is not just about gaming, not just about the Internet; it offers an original window through which to view the world. Computing promises to be the most disruptive scientific paradigm since quantum mechanics. It will transform science and society in profound ways.

Computer science is the true “New Math”—the modern conceptual template for the natural sciences of the 21st century. Classical math gave sciences formulae and differential equations; computer science gives them algorithms. What exactly is an algorithm? Much more than a mathematical formula, it is a self-referential narrative consisting of commands, loops, and conditionals (if X, do Y). Think of Google as a clever algorithm. Or you can even think of an economy, an ecological system, or a social network as an algorithm in action. To make a literary analogy, the mathematics of natural sciences is an anthology of one-liners: formulae and equations that are pithy, insightful, deep, brilliant. Modern physics illustrates how much a few math formulae can do. The algorithms of computer science are more akin to long, messy, infuriatingly complex novels. That is exactly what makes it unique and appealing—computer algorithms can capture nuances of complex reality in a way that standard mathematics cannot.

I'll be the first to admit that, as the recent breakthroughs on Fermat's Last Theorem and the Poincaré Conjecture indicate, the field of mathematics has rarely been more fertile with new ideas. No field of inquiry matches math in intellectual depth and vitality. Having said that, today's math follows in a long, continuous tradition: If a math giant from the past—someone like (Friedrich) Gauss—were to come back to Earth, he would have a lot of catching up to do but he would find that math is done much the same way that it was done during his life.

Computer science, by contrast, is a radically new way of thinking, a new way of looking at all sorts of problems. Classical mathematics can't come near to describing the complexity of large systems (human, biological, or otherwise) in the way that computer science can (or will). The quantitative sciences of the 21st century such as proteomics and neurobiology, I predict, will place algorithms rather than formulae at their core. In a few decades we will have algorithms that will be considered as fundamental as, say, calculus is today.

The power of algorithms is already revealed by the fact that computer science has become integral to all the sciences. Modern biology, for example, is very quantitative and increasingly an “information science,” so a computer science background is imperative. At Princeton, we're retooling the COS curriculum to reflect such connections and the fact that the field is not so much about operating computers as it is about thinking in new ways. For example, I've been part of the pioneering “integrated” course developed by David Botstein and colleagues in computer science, chemistry and physics. The course simultaneously incorporates physics, biology, chemistry, mathematics and computer science. In one lecture, I discussed “Zero Knowledge”—how you and I can convince each other of new facts without revealing anything about them. Some students told me afterwards this completely shattered their intuitive notion of “knowledge.” Mathematics has long been the lingua franca, the Esperanto, of science. But I would argue that science now has two Esperantos: math and computer science.

Given that computer science—in my obviously biased estimation—is perhaps the most exciting field of study one could choose, why are students heading to law school? In part, the dot-com bust scared them. Computer science departments have lost students all across the country. That's why we saw Bill Gates in recent months gallivanting across North American campuses, trying to turn kids on to the field. But also I think that computer science lacks a great popularizer. More than 25 years ago the book “Goedel, Escher, Bach: An Eternal Golden Braid,” by Douglas Hofstadter, got a whole generation of people excited about the future of the field. But today computer science doesn't have anyone the way that, for example, physics has Stephen Hawking or biology has Richard Dawkins—someone who in a sustained way explains to the broader public the beauty and wonder and potential of the field.

I am sometimes asked why students should major in computer science—arent all the programming jobs being outsourced to India anyway? Can you actually get a job if you study computer science? Yes, absolutely, and I am not talking about minimum-wage programming jobs. First, as I said, all the other sciences require the kind of thinking that computer scientists offer. Second, for those of an entrepreneurial bent, the Internet is paramount; if you don’t understand computer science you are lost. I don’t think it is just coincidence that two of the biggest Internet visionaries—Jeff Bezos of Amazon and Eric Schmidt of Google—are products of the computer science and electrical engineering departments at Princeton. Third, and (since I am a theorist) most exciting, are careers in theoretical computer science. The field would exist even if there were no computers. Computer science is not bound by the laws of physics; it is inspired by them but, like mathematics, it is ruled and guided by its inner, autonomous logic.

A few short years before Einstein turned our world upside down with his theory of relativity, the great Lord Kelvin declared, “There is nothing new to be discovered in physics now.” Not his lordship's finest hour. I think that computer science bears an uncanny resemblance to pre-Einstein physics. Moore’s Law—Gordon Moore’s prediction that computing power would increase exponentially because the number of transistors on a microchip would double every 18 months or so—put computing on the map. But count on algorithms to unleash computing’s true potential. I predict that there will be an Einstein of computer science. The revolution is yet to come.
PLOrk: Not your father’s Stradivarius
Orchestra of laptops challenges students’ understanding of music
by Teresa Riordan

Electronic raindrops? A fast-forward reading of Dr. Seuss or a deep moaning that seems to emanate from the bottom of the ocean? A rockabilly jazz melody?

It’s hard to predict just what the Princeton Laptop Orchestra (PLOrk for short) will play next, and that is exactly the point according to computer music mavericks Perry Cook and Dan Trueman, who assembled the orchestra last semester as a freshman seminar and re-fashioned it as a graduate course this semester.

The orchestra is the first of its kind—an experimental group that performs on laptop “instruments” invented specifically for the class. PLOrk gave its premiere performance April 4 in Richardson Hall, with guest performances by Zakir Hussain, a renowned player of the tabla, an Indian percussion instrument; accordion legend Pauline Oliveros; and the percussion quartet So Percussion.

The laptop orchestra is beginning to grab the ear of the media, and is featured this spring in Wired and Technology Review magazines.

At a class last semester, the 15 freshmen broke into ensembles and, seated on red, mauve or brown pillows, performed pieces they had composed themselves.

The first group played a tune with a Euro-pop beat that could have served as part of the soundtrack for the film “Ocean’s 11.” The next was a surreal piece called “The Inner Workings of Anna’s Mind,” which featured the voice of freshman Anna Wittstruck being twisted and contorted beyond recognition. During the final performance, a stocking-footed Bixi “Brian” Zhao danced his ensemble’s bass line on foot-pad sensors.

Trueman, an assistant professor of music, and Cook, an associate professor with joint appointments in computer science and music, see the class as a way to introduce students to the rich field of electronic music and let them explore musical ideas that would not be possible with even the most sophisticated commercially available software. In the end they hope that students see both music and computer science in a new light.

Students played their laptops with Max/MSP, a commercially available software package, and a new music language—known as ChucK—written by Princeton computer science doctoral student Ge Wang.

Only a few of the freshmen had substantial programming experience. But those who didn’t quickly got up to speed.

“It’s ideal,” said freshman Theodore Beers. “I’m a musician, not a programmer, so if I was ever going to learn programming this had to be the way.”

Working with graduate students Wang and Scott Smallwood, Trueman and Cook configured the PLOrk stations specifically for the class. Each unit consists of an Apple PowerBook, a special six-speaker hub, an audio interface, a power unit and a six-channel amplifier. Students supplement their stations by adding keyboards, graphics pads, sensors and other extensions as they see fit.

In Trueman’s office, outside of class, the two professors riffed on each other’s thoughts in a way only two close friends can (Cook was Trueman’s doctoral adviser at Princeton 10 years ago).

They discussed, for example, how ChucK differs from Apple computer’s GarageBand or Image Line’s Fruityloops software—both programs that allow the average person to compose music on a laptop computer.

“Those are not power tools,” Cook intoned with mock snootiness.

Trueman amplified that thought. “When you write in their program you’re submitting to their vision of what music is; with ChucK you have to invent.

You have to construct your own values into your system.”

One of ChucK’s unique characteristics is that it encourages performers to modify code on the fly, while they are performing. This means that the code, or the score, is different at the end of session than it was when the performance began.

Freshman Zachary Marr said that he found ChucK harder to use than commercial programs. “But it gives you a lot more freedom,” he said.

While the programming is technically difficult, the students also are struggling more philosophically with their fundamental conceptions of music.

“There is no one more self-confident than an 18-year-old, especially when it comes to opinions about music,” said Trueman.

“They are having their view of what music is severely challenged,” Cook acknowledged. “But the students have embraced the challenge. “It’s my favorite class,” said Wittstruck.

“The music world all of a sudden is a much bigger place; it’s much more than just playing an instrument.”

Photo by Denise Applewhite
In the fall of 2004, Professor H. Vincent Poor ’77 taught a freshman seminar called “Six Degrees of Separation: Small World Networks in Science, Technology and Society.”

In the course, Poor, who is now the incoming dean of engineering, and his students explored the very hot topic of network theory, which springs from research done in the 1960s by the social psychologist Stanley Milgram. Milgram performed experiments suggesting that most people are connected through surprisingly few “degrees of separation.” This concept of small-world networks—detailed in books like “Six Degrees: The Science of a Connected Age” and “Linked: How Everything Is Connected to Everything Else and What It Means”—has caught fire in the popular imagination.

Poor’s course started us thinking about our own networks. What are the networks that link the Engineering School faculty not only to each other but also to other disciplines, either within Princeton or without?

Thus, we undertook the ambitious effort of mapping some of those connections, with an eye particularly toward unexpected, interdisciplinary projects. In the following six pages you will see just a sampling of the networks we discovered. (See page 20 for a brief description of each project depicted on the map.) We think you will be surprised both by the density of our interconnectedness and also by the breadth of the fields that connect us—from climate change to network theory, from quantum cascade lasers to electronic music.

Such connections exemplify the strategic vision for Princeton Engineering. The most pressing problems in the world today do not fit within the neat confines of single academic disciplines, but require a diversity of backgrounds and expertise. That is why we see Princeton Engineering as a hub that connects science, technology and the needs of society.

The richness of connections also creates a fertile environment for learning. Graduate and undergraduate students benefit from being part of projects that expose them to multiple approaches to solving problems.

As the School of Engineering plans a major initiative in biological engineering, including new faculty appointments, we were aware that about half of our faculty conducts research that touches upon biology. Still, in formulating this map, we were struck by the range of the Engineering School’s biological connections. Ron Weiss in electrical engineering is a pioneer of synthetic biology. Jianqing Fan of operations research and financial engineering and Olga Troyanskaya of computer science are applying their computational power to complex genetic riddles. In chemical engineering, Christodoulos Floudas is wresting with protein folding, and Robert Prud’homme is inventing nano-particles for vaccines. Materials scientist James Sturm ’79 is designing switches for DNA sorting. Mechanical and aerospace engineers Alexander Smits and Philip Holmes are untangling the neuronal schemes of eels and lampreys to enhance robotics research. In civil and environmental engineering, Ignacio Rodriguez-Iturbe and Michael Celia ’83 are working with biologists to understand and protect ecosystems of savannas in sub-Saharan Africa.

While the following chart focuses on cross-disciplinary collaborations, many other projects create substantial impact from fundamental research within specific disciplines. Those are subjects for other stories, which we will continue to tell.

So think of the following pages as a starting point, a random sampling that cannot begin to capture all or even most of the networks that link us. The academic departments create important networks of their own, while cross-disciplinary organizations—such as the Princeton Institute for the Science and Technology of Materials—exist expressly to link people from far-reaching areas. The most important networks, however, extend far beyond Princeton to our academic, industrial and government partners and to the thousands of alumni who carry forward the research and learning that starts here. That is where the work of Princeton Engineering pays off and has its impact.

We hope you will return often to our new Web site at engineering.princeton.edu to keep up with our ever-evolving work and, in doing so, perhaps discover relevant new connections and new opportunities for collaboration. —EQN Staff
Adaptive Ocean Sampling
Optimizing the use of autonomous underwater vehicles as mobile sensors to improve numerical models and forecasts of ocean dynamics and ecology.

Art of Science
An annual competition and exhibit to celebrate the aesthetics of research and the interplay of science, engineering and art.

Bendable Display Panels
Inventing bendable plastic computer screens. Bendheim Center/Princeton University
Encourages interdisciplinary research in finance, primarily from a quantitative perspective.

Bio-Inspired Locomotion
Creating an integrated computer and mechanical model of the swimming ability of a lamprey, which is a model system for vertebrate motion.

Biologically Inspired Materials
NASA-funded program to create aerospace materials that are strong, light and able to self-repair, as in biological systems.

bioPIXIE
A probabilistic system for integrating, analyzing and visualizing diverse genomic data to discover biological networks and pathways.

Biostatistics and Neuroblastoma
Using statistical principles to optimize the use of gene arrays in detecting and discovering treatments for neuroblastoma, a cancer that affects infants and young children.

Block Copolymer Lithography
Discovering ways to align nano-scale patterns over long distances for high-density memory devices and other electronics.

Carbon Mitigation Initiative
Researching safe, effective and affordable strategies—such as carbon capture and storage—for reducing global carbon dioxide emissions.

Communications & Network Alliance
Funded by U.S. Army, mathematical modeling to find the fundamental limits of wireless communications channels.

Correlated Electronic Materials
Understanding the physics of interactions between individual electrons in advanced materials for opto-electronics, telecommunications and quantum computing. With “Nano-Contacts” and “Guided Self-Assembly,” funded by a major grant from the National Science Foundation.

Decision-Making in Animal Motion
Using dynamical systems tools to create numerical models of coordinated animal movements, such as schooling fish.

Detecting Chromosomal Abnormalities
Computer science techniques quickly identify chromosome alterations that could cause cancer.

DNA Transport
Methods for rapidly and accurately sorting DNA of different sizes.

Femtosecond Laser Eye Surgery
Creating eye surgery tool that is less invasive and much more precise than conventional lasers.

Fuel Cells
Creating fuel cells that function with carbon-contaminated hydrogen, while requiring less water and having more durable polymer membranes than other fuel cells.

Fruit Fly Development
Creating a numerical method for simulating how key biological molecules spread across fruit fly eggs, a model system for understanding how organisms develop.

Game Theory for Wireless Networks
Using the work of John Nash, treating the nodes of a wireless network as players in a game competing for space in the radio spectrum.

Guided Self-Assembly
Addressing the fabrication, science and technology of large-scale patterned, addressable and interconnected structures with features on the nanometer to micron scale.

Hypersonics Data Visualization
Developing techniques to visualize detailed simulations of hypersonic turbulence flows, which could lead to new ways to suppress or enhance turbulence.

Implantable Sensors
Designing implantable micro-electro-mechanical devices for monitoring blood flow.

Information Technology Policy
Public policy experts and technologists addressing issues such as privacy and security connected to computer technology.

Joint University Program for Air Transportation
Conducting long-term research and education to improve the efficiency, performance and safety of air transportation in the United States.

 Judgment Aggregation
Developing methods for aggregating the judgments of panels of many, with applications for market forecasting, policymaking and other decision-making.

Learning Theory & Epistemology
An undergraduate course and published research on the philosophical, statistical and algorithmic aspects of inductive reasoning, learning and pattern recognition.

Machine Learning with WordNet
Using machine learning and WordNet, a map of words and their meanings developed at Princeton, to perform image matching, word sense disambiguation and automatic topic finding.

Nano-Contacts
Understanding the physics and chemistry of nano-scale electrical contacts widely used in telecommunication and microelectronic devices.

Nanoparticles for Disease Detection
A U.S.–Africa collaboration to design nanoparticles that target diseased tissue for diagnosis and treatment of cancer, HIV and malaria.

Needle-Free Vaccines
Creating drug nanoparticles with block copolymers that can be inhaled as an aerosol spray.

Network X-ities
Building quantitative foundation for considering hard-to-measure aspects of network performance such as scalability, manageability, survivability and adaptability.

Neural Networks for Analyzing Colon Cancer
Sponsored by National Cancer Institute, using neural network analysis to classify genetic data obtained from colorectal cancer tissue.

Pattern Hunting in Brain Imaging Data
Using signal processing tools to look for patterns in data from brain imaging studies and classify what someone is thinking.

Pervasive Information Technology
Funded by State of New Jersey, developing new devices for and researching the use of information technology for business, education, security and household management.

PlanetLab
A global network of computers that serves as a testing ground for a future generation of the Internet.

Plasma Science & Propulsion
Collaborations with the Princeton Plasma Physics Lab, including plasma-driven rocket propulsion, numerical simulations of plasma fluid flows and development of advanced laser-based diagnostics.

Predicting Protein Function
A methodology for predicting function for unknown proteins from heterogeneous data sources using machine learning.

Princeton Environmental Institute
Coordinates environmental education, research and outreach activities at Princeton.

Princeton Laptop Orchestra (PLOrk)
Ensemble of performers playing computer-based instruments, each consisting of a laptop, a multi-channel speaker and a variety of control devices.

Program in Applied and Computational Mathematics
Interdisciplinary program fosters teaching and research in branches of mathematics indispensable for science and engineering applications.

Program in Computational and Quantitative Biology
Through the Lewis-Sigler Institute for Integrative Genomics, the program integrates graduate education in genomics, biophysics, computational neurobiology, systems biology, population biology and quantitative genetics, molecular evolution, computational biology, and microbial interactions.

Protein Folding
Using optimization techniques to predict protein folding, a seminal problem in biology. Results used to identify a better anti-inflammatory drug.

Quantum Cascade Laser Sensors
Inventing and optimizing tunable laser sources, detectors and ultra-sensitive sensor systems that have medical, environmental and homeland security applications.

S&P 500 Behavior
Minute-by-minute analysis of stock index reveals shifting patterns in recent decades.

Structures & Structural Art
Research projects and teaching programs that combine architectural design and structural engineering, as well as the science and technology of building material conservation.

Synthetic Biology
Combining electronics and biology to program the behavior of cells for use in tissue engineering, biosensing and biomaterial fabrication.

Terrestrial Planet Finder
Designing a space-based telescope for detecting Earth-like planets around other stars.

Water, Savannas and Society
Studies the effects of changes in water dynamics on the ecological structure of African savannas and the socioeconomic well-being of the regional population.

ZebraNet
Creating a high-efficiency wireless network among herd animals in Africa to collect behavioral information for ecologists.
Teaching Awards

Of the many honors that Princeton Engineering faculty members receive, one of the most highly valued comes not from an international panel of authorities, but from their own students. Each semester for the past 18 years, the E-Council, an organization of undergraduates, has given its Excellence in Teaching awards to recognize outstanding teachers in engineering and the sciences. At the fall 2005 ceremony, held in December, Dean Maria Klawe (left) and President Shirley M. Tilghman (far right) congratulated the winners (from left to right): graduate student Sinead MacNamara, Brian Kernighan, Pablo Debenedetti, grad students Benedict Brown and Katsuyuki Wakabayashi, and lecturer Donna Gabai. Ronnie Sircar and graduate student Kumar Raman also won awards but are not pictured. The quotes on this page are a fraction of the praise students heaped upon their teachers.

Sinead MacNamara
Graduate student in civil and environmental engineering

“Sinead forced us to visualize a problem, not just solve given equations. She went through each problem with us, and showed us lots of examples. If we still didn’t understand, she would explain again. She has to be the most patient person in the world.”

Brian Kernighan
Professor of computer science

“On the first day of class, Prof. Kernighan took pictures of the entire class with a digital camera. By the second class he knew all of our names, and by the third I had to wait in line to speak to him after class.”

“We got to hear the history and the stories from his years at Bell Labs. We not only learned to use C++, we learned why a particular design decision was made in its development—because Brian was there.”

Pablo Debenedetti
Professor of chemical engineering

“He made a potentially crazily hard topic as easy as possible and tried to gently nudge the material into our heads any way he could.”

“If we didn’t get what he lectured on the first time or the second, we could ask for a third, fourth, fifth or even sixth try in office hours or meetings to fit our schedules.”

Benedict Brown
Graduate student in computer science

“Whether an assignment was due in a week or in five minutes, whether it was 2 in the afternoon or 2 in the morning, he welcomed us in his office and responded to e-mails like nobody’s business.”

Katsuyuki Wakabayashi
Graduate student in chemical engineering

“If I could be a TA, I would want to be like Kat the most!” “Kat had a way of explaining free energy curves and phase diagrams that just made the subject so much more clear—more pleasurable.”

Donna Gabai
Lecturer in computer science

“Her passion and excitement for the material that she loved shone brightly and created that same spark in her students.”

These are not just world-class teachers but also world-class scholars. They epitomize a chemistry between teaching and scholarship that other institutions try to emulate but which is unique to Princeton.

—Shirley M. Tilghman

Kumar Raman *05
Graduate student in physics

“He was amazing. He rejuvenated my interest in the subject and was entertaining and friendly and took the time to get to know everyone.”

Ronnie Sircar
Professor of operations research and financial engineering

“His teaching style is phenomenal. It was engaging, intellectually stimulating, and always very clear and understandable...this made attending class and doing work a true pleasure.”

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An innovative curriculum that weaves hands-on laboratory learning into traditional academic coursework in engineering, math and physics has given several dozen freshmen a unique introduction to engineering this year. In the integrated course (called EMP, an acronym for Engineering, Math and Physics), students must marshal what they learn in the classroom and apply their knowledge to real-life engineering problems.

“We are using the labs to introduce the whole idea of engineering, which is really about trade-offs,” said incoming dean H. Vincent Poor ’77, director of the Center for Innovation in Engineering Education, which created the new curriculum. “You don’t see the trade-offs as clearly in the classroom as you do when you have to physically build and operate something.” That could not have been truer this spring semester as students go through a series of three labs on energy, robotics, and imaging and data transmission.

Chemical engineering professor Pablo Debenedetti led the first three-week unit on energy. Debenedetti and guest lecturers, including an energy policy advisor to the White House, gave students a broad overview of energy issues in the classroom. The students then went into the lab to make cars powered by solar cells, which make electricity from sunlight, and fuel cells, which make electricity from hydrogen.

“We went from hearing the idealized picture that was presented in the lectures to seeing how a fuel cell actually works,” said Debenedetti, noting that students struggled to get constant voltage and amperage from their cells. “It gets you to think what it would take to actually make this work steadily in a commercial environment.”

Michael Littman, professor of mechanical and aerospace engineering, is leading the robotics lab. Stephen Lyon of electrical engineering, Jennifer Rexford of computer science and William Massey ’77 of operations research and financial engineering organized the data and imaging lab.

In the fall, Dan Marlow, chair of the physics department, led students through a semester-long project to build water-propelled rockets, which contained circuitry and an accelerometer that the students also made. The semester culminated in blasts of water and torrents of data as the rockets rose high over Poe Field.

“EMP Lab has been so cool,” said freshman Jennifer Lee. “Prof. Debenedetti’s lectures have been very engaging, bringing us from background knowledge in chemistry and physics to a serious issue confronting today’s world, the hydrogen economy. Then, we were able to apply this knowledge and cultivate our interests in solar cells and fuel cells by getting to build and run modules that combined the two. I’ve learned so much from my instructors as well as my teammates, who have been a lot of fun to work with.” —SS
Entrepreneurial engineering course fosters creativity

“It’s a winner!” exclaimed Tim Hawthorne, an infomercial producer who was part of a panel of experts judging the final class presentations in January for the course “Entrepreneurial Engineering” (MAE435).

Hawthorne was commenting on the WetterVac, a vacuum cleaner attachment that picks up wet household spills. And indeed it was a winner. The student team who invented the WetterVac signed a licensing deal in March with A.J. Khubani, the CEO of Telebrands, a direct-marketing company.

Khubani co-taught the course with Daniel Nosenchuck, associate professor of mechanical and aerospace engineering.

Half of the students in the course were from outside the Engineering School. “We had teams of students with a mix of backgrounds, skills and interests,” Nosenchuck said. “Those kinds of collaborations mirror what happens in the real world.”

The WetterVac was dreamed up by Lawrence Azzaretti, a history of science major, who teamed up with fellow seniors Jonathan Brosterman (ORFE), Robert Gonzalez, (politics), Robert Moore, (ORFE) and Sameer Shariff (EE). The students spent their spring break in China, at Khubani’s expense, touring a manufacturing plant that will likely produce the WetterVac. They are all listed as co-inventors on a patent application for the invention.

The class was supervised by an Industrial Directors Board whose members guest-lectured to the class and provided expert advice. Board members included Mitchell Modell, CEO of Modell’s Sporting Goods, and Jane Dyer, the director of home division merchandising for the Home Shopping Network.

Two other teams gave final presentations. Andrew Dayton (politics), Edward Wieser (MAE), Mark Daniels (astrophysics) and Christopher Bosco (MAE) teamed up to pitch their hair-straightening invention. Nikki Laffel (Woodrow Wilson School), Meka Asonye, (economics), Paul Rosa (MAE) and Pete Galie (MAE) worked together to develop a plastic window insulation system.

“This wasn’t like every other course where you’re doing problem sets each day,” said Asonye. “It was great to have to an opportunity to be very creative in a traditional academic setting.” —TR

Computer science major wins Goldwater scholarship

Lester Mackey, a junior majoring in computer science, has won a Goldwater Scholarship, one of the nation’s most prestigious scholarships for undergraduates.

Mackey is a among 323 students nationwide, including four at Princeton, who will receive the scholarship, which is awarded by the federally endowed Barry M. Goldwater Scholarship and Excellence in Education Foundation. According to the foundation, Mackey plans to pursue a Ph.D. in computer science after graduating. His goal is to “conduct research in algorithmic analysis/computational complexity that when combined with advances in human computer interaction will allow for more efficient dispersal of digital information.”

In 2004, Mackey, of Wheatley Heights, N.Y., was named a Microsoft Scholar, received the Shapiro Prize for Academic Excellence and received Princeton’s Freshman First Honor Prize, awarded each year to a sophomore in recognition of exceptional achievement during the freshman year. He sings in the Chapel Choir and with the Music Outreach Program, which performs for nursing homes in the community. He has been active in the Princeton Evangelical Fellowship.
A team of Princeton Engineering undergraduates who were surprise finalists in the highly competitive DARPA Grand Challenge last fall is refining their robotically operated pickup truck in hopes of entering new competitions.

“We would like to branch out and have more professors and graduate students involved in our work,” said Gordon Franken, a sophomore in mechanical and aerospace engineering. “This is a serious research group with potential for making breakthroughs in areas like vision-controlled navigation. It would be nice to turn Princeton into one of the big names in autonomous vehicles.”

The group, which has members from all departments within the Engineering School, calls itself PAVE for Princeton Autonomous Vehicle Engineering. The group meets weekly to discuss ideas and work on their vehicle.

The DARPA Challenge, sponsored by the Department of Defense, was a 150-mile race across the Mojave Desert for vehicles that stayed on course and avoided obstacles without any human input. The Princeton team entered the DARPA competition with a 2005 GMC Canyon pickup truck rigged with a global positioning system, video cameras and computer-operated control mechanisms. After numerous qualifying trials, the Pentagon selected the Princeton team from among 195 original contenders for final race in the Mojave. A faculty-led team from Stanford University won the competition, but the Princeton students earned kudos from many observers.

“They did an excellent job,” said Anthony Tether, director of DARPA. “Their vehicle was superb in its simplicity yet effective in its approach. Princeton can be proud of their achievement and advances in computer science and control theory.”

While Alain Kornhauser, professor of operations research and financial engineering, acted as an enthusiastic faculty advisor and cheerleader, the students did most of the engineering themselves.

“If I had been a freshman at Carnegie Mellon or Stanford or MIT I wouldn’t have been involved at all or I would have been a peon working for a graduate student who was working for a professor,” said Franken. “That’s the fabulous thing about Princeton. It’s a place where a group of undergraduates can go out and enter a national competition like this.”

Anand Atreya, a junior in electrical engineering, said the DARPA project was a great complement to his academic work. “It’s not like a problem set where you apply one concept—it’s taking all the stuff you know and integrating it.”

With the help of alumnus Richard Spina ’83, Kornhauser obtained the salvaged pickup truck for the group from General Motors. Katherine Kornhauser P03, president and co-founder (with Alain Kornhauser) of ALK Technologies, donated global positioning equipment. Applanix Corp. also donated global positioning system equipment.

PAVE is now looking for new funding and possibly a new vehicle. “Having limited funds has forced us to be creative,” said Franken. “But at the moment our research budget is hovering just above zero.” The group anticipates that DARPA will issue a new challenge, possibly in an urban environment and has begun planning the new control systems it will need to stay on course. —SS

**Momentum from the Mojave**

Self-driving vehicle group seeks new challenges

An engineering student was among 40 U.S. students to win 2006 Gates Cambridge Scholarships, which give outstanding students from outside the United Kingdom an opportunity to pursue postgraduate study at the University of Cambridge.

Christopher Bohn, who is from Monument, Colo., is a chemical engineering major and a candidate for certificates in finance and bioengineering. He plans to pursue further studies in chemical engineering at Cambridge.

Gates Scholarship awarded to chemical engineering major

Among his activities at Princeton, Bohn has coordinated German-language story hours for the Cotsen Children’s Library; worked as an editor and Web site manager for Business Today, a student-run business magazine; provided academic advising for freshmen as an undergraduate fellow at Mathey College; and performed with the SymphoG breakdancing troupe.
Thinking big, senior turns laptop and ORFE classes into a winning hand

A conversation with Robert J. Moore

Robert J. Moore, a senior majoring in operations research and financial engineering (ORFE), hasn’t graduated yet but is already an established entrepreneur (and sometime rapper). During his undergraduate career, Moore has juggled a number of enterprises, from a website that dispenses college admissions advice to online sales for poker software. We caught up with Moore shortly before he left for China with four fellow Princeton students over spring break to hammer out details of a licensing deal for their WetterVac invention (see page 23).

First things first. How did you get started rapping at Princeton?
Nate Domingue, MAE ’06, and I became friends in a class on satire. We made up P-Unit as a parody of G-Unit and rapped a song that dug into Top 40 rappers. We put it online mainly because we didn’t have any other way to turn it in to the professor. Within two to three months a quarter-million people had downloaded the video.

What is your most profitable business?
Definitely the poker stuff. My Mooraculator improves your chances of winning Texas Hold’em poker by calculating the odds that a given hand will prevail against other players.

How did the Mooraculator come about?
The original desktop software is based on a concept used in operations research called “expected value.” In poker it’s called “pot odds.” It’s a really simple principle that I built into a piece of software.

I signed a licensing deal with a company that wanted me to develop the same thing on a handheld device. At the time, I was a young junior in the ORFE department so I had not really got into the practical stuff on how to do this. I would sit in class, take notes, walk back to my dorm room and send an e-mail to the device’s manufacturers in China saying, “Okay, we’re going to use Monte Carlo simulations,” and teach them what I had learned in class about 20 minutes earlier.

What does your dorm room look like?
There’s a bed, a dresser, a television.

No filing cabinets and boxes of paperwork?
All of my operations are out of my laptop.

Have you ever taken Ed Zschau’s class on High-Tech Entrepreneurship?
Actually almost all of my business partners on campus and I are in his class this semester. I was concerned that it might be a lot of repeat information. But it is not. Zschau is phenomenal. His resume is astounding—former congressman, entrepreneur, venture capitalist.

Once the new ORFE building is established I think there will be more opportunity for business courses. A business-focused, ORFE-focused certificate program would be great.

Why did you decide to do your thesis on Texas Hold’em?
I was NOT going to do poker for my thesis. I enjoy having a million different things going on and I thought I had pushed the poker thing to its limit.

We had a big meeting with the department, and all the professors talked about the areas they were interested in. [ORFE Department Chair Robert] Vanderbei got up and started talking about poker. He said, “This is fascinating to me because it’s a complex multi-stage dynamic stochastic process—there’s no way to get an optimal value because there are unknowable uncertainties in your opponent’s brain. However, can you approach a near-optimal solution so that you can make money on this thing? It’s a really interesting proposition!”

By the end of his speech, most of the room was staring at me.

What is beautiful about Texas Hold’em poker is that it uses all these ORFE tools that are incredibly valuable in industry and finance generally. In fact, Frank Macreery, CS ’06, Sameer Shariff, CS ’06, Kevin Shi, ORFE ’06 and I are using Mooraculator-like tools on our website whatsmyimage.com.

Why did you choose to major in Operations Research and Financial Engineering?
ORFE has allowed me a lot of freedom, and freedom is very valuable to me. Sure, my thesis is on solid academic ground but still—it is a thesis on how to play poker. The academic merit of that might have been questioned elsewhere, but I have never hit even a speed bump at ORFE; I have had nothing but encouragement from the department. I can’t name a professor I had who hasn’t been an important mentor.

Why are you taking a job after graduating instead of starting a new business?
Initially when Insight Venture Partners offered me a job I said, “I can’t do it.” But they said, “Look, you can start your own business right now and it will be pretty big. But think of what you’ll learn and what kind of contacts you will make if you come and work for us first.” After spending [last] summer working with them, I realized that the prospects they were offering were very real. When I’m done at Insight, which is a terrifically smart venture capital firm, I will be able to hit the ground running with something tremendous in size.

To learn more about Moore’s sketch comedy Grounds for Expulsion as well as how a cheesesteak mogul gave him his first big break and why he knows from personal experience how difficult it is to paint a toner factory, see an expanded version of this interview at www.princeton.edu/engineering/news/eqn.
New look at old construction technique could yield cleaner water

by Hilary Parker

Just a few years ago, Bernice Rosenzweig wasn’t quite sure what engineers did and never encountered them. Now a second year Ph.D. candidate in the Department of Civil and Environmental Engineering, Rosenzweig is seeking to engineer a new approach to improving water quality.

Her work focuses on man-made detention ponds, which are regularly included in new construction projects. Designed to retain excess stormwater resulting from the increase in impervious surface with development, the ponds release runoff slowly to prevent flooding and excessive erosion of stream channels. They also reduce the amount of sediment entering waterways.

In her research, Rosenzweig is looking for ways in which the ponds might be used to solve another environmental problem: high levels of dissolved nitrogen compounds, which often come from heavy use of fertilizers. Her goal is to design ponds that capture nitrogen contaminants and alleviate problems such as eutrophication, which occurs when excess nitrogen spurs too much algal growth, which depletes oxygen and chokes the ecosystem.

“I was interested in environmental engineering because I wanted to use my basic environmental science and geology background and apply it toward real-world problems,” Rosenzweig said. After completing her undergraduate degree in Environmental Geology at Douglass College of Rutgers University, she wanted to design creative solutions to real-world problems, which led to engineering. Her advisor at Princeton, Peter Jaffe, a professor of civil and environmental engineering, said that Rosenzweig looks at detention ponds in a new light by viewing them as “mini, created wetlands.” Her work addresses the lab’s overarching question of how biogeochemical cycles function in created environments, and how contaminants can be immobilized.

“She’s a very enthusiastic person,” Jaffe said. “She’s very strong in combining experimentation and numerical modeling.”

For the past year, Rosenzweig has been collecting stream water samples from Harry’s Brook—a watershed encompassing parts of Princeton Borough and Township. The watershed is an ideal lab for her research given its varied development history. The area developed earliest, along Nassau Street, was urbanized and developed without detention ponds. The Terhune Road area, developed later, contains multiple types of detention ponds with different management practices, and Herrontown Woods serves as the forested control.

This spring, she will collect soil samples from the detention basins throughout the watershed and analyze them for the presence and concentration of a variety of nitrogen species. While she expects that some ponds will retain nitrogen effectively, she anticipates that some may actually be a source of nitrate—a contaminant of serious concern to water quality—because of chemical changes that could occur if the ponds dry up and refill.

Rosenzweig is ready for new challenges her research may bring, but also is keeping an eye on the broader issue of how her field attracts young women like herself who might not appreciate the opportunities to make a positive difference through engineering. Through her involvement with Graduate Women in Science and Engineering (GWISE), she is helping to coordinate an engineering career fair that will bring engineering students and professors to high schools in New York City to teach female students about engineering and its varied career options.

In a display of nearly endless energy, she also finds time to precept two classes—CEE 306 Hydrology and CEE 308 Environmental Engineering Laboratory. With all this on her plate, she still manages to practice three times a week with the Princeton capoeira student group. Capoeira, which began with African slaves in Brazil, is a dance-tinged martial art form set to music.

Just as she likes to combine physical fieldwork with complex mental analysis in her academic life, she enjoys the body and mind experience of capoeira.

“It’s just the perfect activity,” she said. “A combination of athletics and movement, with a lot of strategy involved. It’s both a mental and a physical experience.”
Conference sparks dialogue on women in science and engineering

by Elizabeth Landau

Florence Hudson ’80 always knew that she wanted to have two to three children, and that she didn’t want to stop working. As vice president for strategy and marketing for the Global Industrial Sector for IBM, she found herself taking 7 a.m. conference calls from India and China while her children needed to get ready for school.

“It’s more frustrating for the kids when I’m on a conference call and they can see me, but they can’t have me,” said Hudson, who now tries to keep more separation between work and family. “You really have to think about what works best for you.”

Hudson and other professional women shared their experiences and advice with more than 100 women at the Women in Science & Engineering Conference in February. Undergraduate and graduate students from Columbia, University of Pennsylvania, New York University, Rutgers, and Princeton convened in the Friend Center to learn about leadership skills, career options, and balancing work and home life.

Maria Klawe, dean of engineering, opened the conference by telling participants about the evolution of her own attitudes about gender in science. Growing up at a time when it was thought that women cannot do math or science, Klawe thought that she herself was more like a boy than a girl.

“I just thought men’s set of values were the right set of values, and women were just mixed up,” she said. “I figured out this was wrong when I became a manager at IBM at age 30.”

At IBM she realized that all the women in her group had just as much of a right to encouragement in the sciences as she did, regardless of how different they were from herself.

“It’s not so much about gender but about creating a culture that is encouraging towards diversity,” she said.

Following Klawe’s talk, Princeton Engineering professors Jennifer Rexford ’91, Kyle Vanderlick and Catherine Peters led discussion groups on time management, negotiation and “dealing with difficult people.”

Hudson was part of a panel with professors and researchers from Columbia, Princeton, Rutgers, the Society of Women Engineers and Penn, who discussed how to balance a career in science and engineering with social and family life.

The women have all found time for both work and family, as well as social activities. Nonetheless, they have had to deal with daycare and nanny issues, and have to make adjustments to make everything fit into their schedules.

“It’s our children’s reality that they have working mothers and fathers, and sometimes they just have to get used to it,” said Tal Rabin, head of the Cryptography and Privacy Research Group at IBM.

Another panel discussion focused on career choices, including the pros and cons of academia and industry. Professors from Princeton and Penn contrasted their experiences with researchers at Arup, Google, New York City Transit, and Telcordia Technologies.

Naomi Leonard ’85, professor of mechanical and aerospace engineering, said she enjoys the freedom that her job at Princeton allows.

“This is the kind of place where you really can do whatever it is you want to do,” she said. “The downside is that there are so many things to do.”

Industry researchers also said they have freedom in their jobs. Corinna Cortes, who works in machinery at Google, likes that her industry work is closer to real problems.

“An enormous number of professors come to us and say, ‘Give us a real problem to solve,’ she said. “We have the same opportunities as university professors going to conferences. To me, it’s a no-brainer.”

Connie Crawford ’78 ’81, who has bachelor’s and master’s degrees in civil engineering from Princeton, is now chief engineer at New York City Transit, but experienced both worlds when Princeton hired her to teach bridge engineering in the 1990s.

“Teaching was a wonderful instrument to help me, being in industry,” she said. “I was imparting what I had been learning in industry.”

The conference was sponsored by Google, IBM, the Princeton Department of Computer Science, Graduate Women in Science and Engineering at Princeton (GWISE), and the Princeton School of Engineering and Applied Science.

Graduate Engineering Ambassadors

The newest graduate student organization at Princeton Engineering is the Graduate Engineering Ambassadors, which was created in 2005 by Jenny He, a graduate student in electrical engineering, and Stephen Friedfeld, associate dean for graduate affairs. The group welcomes and helps recruit prospective students and represents the school at outreach events aimed at promoting interest in science and engineering. In its first year, the group sent e-mails to all newly accepted graduate students and created welcome packages for all visiting accepted graduate students. The group members also met with prospective graduate students during Visit Days and traveled to other campuses to recruit undergraduate students to apply for graduate work at Princeton. The group also participated in the annual Science and Engineering Expo, which brought 800 middle school students to campus for a day of hands-on activities.

Members of the Graduate Engineering Ambassadors group are (from left) Anish Muttreja, Najwa Aaraj, Melissa Carroll and Jayue (Jenny) He.
Sau-Hai (Harvey) Lam, the Edwin Wilsey ’04 Professor Emeritus of Mechanical and Aerospace Engineering, has been elected to the National Academy of Engineering, which is among the highest honors of the engineering profession.

The academy cited Lam for his “contributions to aerospace engineering in the areas of plasma flows, combustion, turbulence and adaptive controls.”

Lam, who received his Ph.D. from Princeton in 1958, joined the Princeton faculty two years later. He led an active career as a teacher, researcher and administrator for four decades, transferring to emeritus status in 1999.

Lam was among 76 new members elected to the academy this year, including three other Princeton alumni: Thomas Koch, who earned a bachelor’s in physics in 1977 and is now a professor of computer and electrical engineering at Lehigh University; Stephen Jaffe, who received his Ph.D. in chemical engineering in 1968 and is a distinguished scientific advisor at ExxonMobil Research and Engineering; and Eric Schmidt, who received a 1976 bachelor’s in electrical engineering and is now CEO of Google.

Lam’s election brings to 20 the number of faculty members in the School of Engineering and Applied Science who are members of the National Academy of Engineering.

Two Princeton engineers receive NSF CAREER awards

The National Science Foundation has granted CAREER awards, its most prestigious grants for scientists early in their careers, to two Princeton Engineering faculty members, Craig Arnold and Olga Troyanskaya.

Arnold, an assistant professor of mechanical and aerospace engineering, received a $500,000, five-year grant for a project aimed at developing new ways of processing materials that could result in improved batteries and other devices. His project involves using lasers to modify materials used in batteries and conducting rigorous studies to understand the relations between the processing techniques and the materials’ performance. The grant is titled “Laser Modified Transport in Electrochemical Materials.”

Troyanskaya, an assistant professor of computer science and the Lewis-Sigler Institute for Integrative Genomics, received a five-year grant of $1 million to combine computational and experimental techniques for analyzing networks of biological processes within organisms. Part of her project, “An Integrated Approach to the Study of Biological Process Specific Networks,” involves analyzing genomic data and creating computer models that simulate biological networks. Another part focuses on lab experiments to test the validity of the computer models. Combining these approaches, Troyanskaya expects to develop computer models that are faster than lab experiments and more accurate than purely computational methods.

The CAREER program supports young, tenure-track “teacher-scholars who most effectively integrate research and education within the context of the mission of their organization.” The grants are intended to “build a firm foundation for a lifetime of integrated contributions to research and education.”

Center for Innovation in Engineering Education appoints key positions

The Center for Innovation in Engineering Education has recruited two outstanding scholars/teachers to hold the position of Kenan Trust Visiting Professor for Distinguished Teaching for 2006-07. Edward Coyle ’82, of Purdue University, will be appointed in the electrical engineering department. Coyle pioneered a program called the EPICS Entrepreneurship Initiative, which combines engineering, community service and entrepreneurship. He is a co-recipient of the 2005 Gordon Prize from the National Academy of Engineering. Richard DeVcaux ’73, whose appointment will be in operations research and financial engineering, is currently a professor of statistics at Williams College. During a previous appointment at Princeton, he received six E-Council Teaching Awards, earning him the council’s Lifetime Achievement Award.

The center also hired entrepreneur and former technology executive Bob Monsour to fill a key staff position: the Associate Director for External Affairs. Monsour, whose career has included a variety of management roles in startups as well as publicly held technology companies, will build relationships with industry to foster more practical engineering experience for undergraduates through internships, research projects and other programs.

Prucnal edits book on emerging optical networking technology

CRC Press has published Optical Code-Division Multiple Access: Fundamentals and Applications, edited by Paul Prucnal, professor of electrical engineering. Code-division multiple access (CDMA) is a data transmission technology that is crucial to cell phone networks and is being adopted in optical networks. According to CRC Press, Prucnal’s book features “contributions from a team of international experts led by a pioneer in optical technology” and “places the concepts, techniques, and technologies in clear focus for anyone working to build next-generation optical networks.”

Sedgewick sells 500,000th copy of Algorithms in C++

Computer science professor Robert Sedgewick’s Algorithms in C++—which has been translated into a dozen languages—has sold its 500,000th copy. “The book’s success is due to its appeal across audiences with different needs,” said Peter Gordon, Sedgewick’s editor at Addison-Wesley. “It is at once a pedagogically rich textbook for students at both undergraduate and graduate levels of study and also a practical resource for professional programmers.”
Faculty awards and honors

Li-Shiuan Peh, assistant professor of electrical engineering, has been awarded a Sloan Research Fellowship, a prestigious early-career award that supports a small number of young faculty members across a range of scientific disciplines. Peh was among 116 U.S. and Canadian researchers to receive the fellowship, which includes $45,000 in unrestricted research funding over a two-year period.

Peh, who received her Ph.D. in 2001 from Stanford University, researches interconnection networks, an increasingly important method of connecting multiple computer processors on a single chip. Peh’s work involves creating networks of processors that use power efficiently and perform well across a range of network sizes.

Daniel Tsui, Arthur Legrand Doty Professor of Electrical Engineering, has received the 2005 Distinguished Science and Technology Award from the American Chinese Institute of Engineers (CIE-USA). The goal of the institute is to serve the engineering society and serve as a forum for engineers who were educated in both China and the United States. Tsui, a 1998 Nobel Laureate in physics, studies the electrical properties of thin films and microstructures of semiconductors. He has been a member of the Princeton faculty since 1982.

Ignacio Rodriguez-Iturbe, professor of civil and environmental engineering and the Theodora Shelton Pitney Professor in Environmental Sciences, has been elected an honorary member of the National Academy of Engineering of Venezuela.

Alexander Smits, professor of mechanical and aerospace engineering, was elected vice-chair of the Division of Fluid Dynamics of the American Physical Society, has been elected an honorary member of the National Academy of Engineering of Venezuela.

Chung K. Law, Robert H. Goddard Professor of Mechanical and Aerospace Engineering, delivered the conference plenary lecture entitled “Fifty years of magnificent combustion research in Japan” at a symposium celebrating the 50th anniversary of the founding of the Japanese combustion society.

Jeremy Kasdin ’85, associate professor, and Yiguang Ju, assistant professor of mechanical and aerospace engineering, have been made associate fellows in the American Institute of Aeronautics and Astronautics. They share this honor with Ihab Girgis, mechanical and aerospace engineering researcher and lecturer for 2006.

Sandra Trojan, professor of chemical engineering, has been elected a fellow of the American Physical Society, which honored her for her work in “pioneering theoretical, experimental, and molecular simulation studies of micro-hydrodynamic flows.” APS lifetime fellowships recognize original research and publication, contributions in the application of physics to science and technology, contributions to the teaching of physics, or service and participation in the society.

Stephen Forrest, professor of electrical engineering, has been elected a fellow of the American Physical Society, which honored her for her work in “pioneering theoretical, experimental, and molecular simulation studies of micro-hydrodynamic flows.” APS lifetime fellowships recognize original research and publication, contributions in the application of physics to science and technology, contributions to the teaching of physics, or service and participation in the society.

David Billington ’50, the Gordon Y.S. Wu professor of civil and environmental engineering, served as the Robert N. Noyce Visiting Professor at Grinnell College during the winter of 2006. At Grinnell, Billington gave a series of lectures on structure as an art form. The lectures coincided with the opening at Grinnell of an exhibition curated by Billington on the work of four Swiss architects, The Art of Structural Design: A Swiss Legacy.

The Engineering School received a letter of commendation from Raytheon Missile Systems recognizing the contributions of Garry Brown, the Robert Porter Patterson Professor of Mechanical and Aerospace Engineering, in helping to solve a critical problem in the development of the Tactical Tomahawk missile system. “Dr. Brown’s keen insight and understanding of fluid dynamics and associated modeling techniques provided that ‘kernel of knowledge’ necessary for solving a key problem with the missile’s attitude control system, according to Raytheon.

Pablo Debenedetti, professor of chemical engineering, presented the 2006 James M. and Catherine T. Patten Distinguished Lecture at the University of Colorado in March. Debenedetti, who is Princeton’s Class of 1950 Professor in Engineering and Applied Science, spoke on the subject of “Confinement, Hydrophobicity and Supercooling: What is Special about Water?”

Robert Jahn ’51 *55, emeritus professor of mechanical and aerospace engineering, has received the first Edgar Mitchell Award for Noetic Leadership. The Friends of Noetic Science also honored Jahn’s long-time research partner Brenda Dunne for her 27 years of accomplishments as laboratory manager of the Princeton Engineering Anomalies Research program. Jahn, a pioneer of the science and technology of plasma propulsion for spacecraft, joined the Princeton faculty in 1962 and served as dean of engineering from 1971 to 1986.
Augustine receives Public Welfare Medal

The National Academy of Sciences has chosen Norman Augustine ’57 *59 to receive the 2006 Public Welfare Medal, the academy's most prestigious award. Augustine, the retired chairman and CEO of Lockheed Martin, has been a visiting lecturer at Princeton’s Department of Mechanical and Aerospace Engineering, currently serves on the department's advisory council and has been a trustee of Princeton University.

The medal honors Augustine’s “contributions to the vitality of science in the United States by bringing to industry and government a better understanding of the crucial role that fundamental research must play in our long-term security and economic prosperity.”

“Our entire nation—and its scientific and engineering enterprises in particular—owes an enormous debt to Norm Augustine,” said Ralph Cicerone, president of the National Academy of Sciences. “Acting on his strong personal conviction that sound national policy must embrace the very best in science and engineering, he has personally made a very real difference in our nation’s life and to its welfare.”

In addition to his long career with Lockheed Martin and its predecessor, Martin Marietta, Augustine has chaired important National Research Council study panels that have shaped U.S. science and technology policy.

“Norm Augustine is an effective advocate for wise long-range policies in the mostly short-range world of Washington policymaking,” said John Brauman, who chaired the selection committee for the award. “He is a talented leader with the ability to cut through complex issues quickly and bring diverse groups of people together to focus on getting results.”

Papa returns to campus with lessons in entrepreneurship

The way Steve Papa tells it, his company has survived just about everything but a plague of locusts.

Papa, a 1994 graduate in civil engineering, returned to campus in February to regale a near-capacity audience in the Friend Center auditorium with the trials and tribulations of building Endeca, his extraordinarily successful information technology search company.

Things started easily for the company in 1999—perhaps too easily, according to Papa.

“It was the dot-com craze,” said Papa. “We raised $1 million in three days.” Soon the company had its first customer, Fidelity Investments.

But then came the dot-com crash, the 9/11 terrorist attacks, and an anthrax scare that landed Endeca on national news.

It would be 13 months before Endeca got its second customer. Slowly and steadily the company built up to the 300 customers it has today, most of them federal agencies or brand-name companies like Wal-Mart and Home Depot.

In telling the history of Endeca, Papa offered a blueprint for others embarking on new business ventures. Among his suggestions:

* Hire people you know and trust and who, in turn, believe in you. About half of the company’s pioneer employees were people Papa knew from Princeton. 

* Act with integrity. Start-ups should be relentless in establishing their credibility.

* Be agile. Entrepreneurial adaptation is essential to a high-growth business.

Papa’s talk was the second in a Technology Entrepreneurship Lecture Series jointly sponsored by Princeton’s Center for Innovation in Engineering Education (CIEE) in collaboration with the Jumpstart New Jersey Angel Network. J. Christopher Dries *96, *99, vice president for research and development at Sensors Unlimited, gave the first lecture of the series last November, titled “Boom, Bust, and Bounce . . . Anecdotes of Life in a Small, High-Tech Business.” On May 4, the third lecture in the series will feature a panel discussion between three Princeton alums. The panelists will be Karen Drexler ’81, who co-founded and served as CEO of America Medical; Jim Furnivall ’80, general partner of Canaan Partners; and Kef Kasdin ’85, a general partner at Battelle Ventures.

Augustine receives Public Welfare Medal

Photo courtesy of Endeca

Photo courtesy of Lockheed Martin

Photo courtesy of Lockeed Martin
From spacewalks to CBS survivor, Barry shows his mettle

Now that he has returned from “Survivor,” having been voted off the island in the sixth round, Barry is eager to move on to his next challenge.

After retiring from NASA in 2005, Barry founded Denbar Robotics to create robotic assistants for people with disabilities. He has a long-standing interest in the field, and explored it during his tenure as an assistant professor in the Department of Physical Medicine and Rehabilitation and in the Bioengineering Program at the University of Michigan (in addition to his Princeton degrees, he has a M.D. from the University of Miami). “It’s a very long term goal,” he said.

Barry, who holds two master’s degrees and a doctorate in electrical engineering and computer science from Princeton, was listed by the Princeton Alumni Weekly as one of “100 Notable Alumni of the Graduate School.”

The University has remained near and dear to him, even in outer space, and Princeton memorabilia traveled with him aboard missions on both Discovery and Endeavor. Barry speaks highly of the education and opportunities he received at Princeton, and said that his time at the University literally changed his life – it was there that he met his wife, Susan Barry (Feinstein), who received a Ph.D. in biology from Princeton in 1980.

“What’s the best thing that happened to me at Princeton.”

by Hilary Parker

Competing on CBS’s reality TV show, “Survivor: Exile Island,” is no walk in the woods, and many might even call it risky. 

Dan Barry ’80, a retired NASA astronaut who logged over 700 hours in space and completed four spacewalks, has a slightly different perspective.

“You’re not really alone,” he said after returning from his “Survivor” stint in Panama, “and you’re not launching on six million pounds of explosives. It’s a whole different level of risk.”

Nonetheless, parallels can be drawn between long-duration spaceflight and “Survivor.” Both activities entail constant monitoring and isolation with a small group of people, as well as “long days with not a lot to do interrupted by emergency moments,” he said.

Briefs

Beatriz Infante ‘76 was appointed CEO of VoiceObjects, a leading company providing the technology for voice-driven automation. Infante, who received her bachelor's degree in electrical engineering and computer science from Princeton and a master's degree from Caltech, currently serves as a member of the Princeton Engineering Leadership Council. Prior to joining VoiceObjects, Infante held numerous leadership positions in the technology industry, including serving as CEO of Synchron Technology and president and CEO of Aspect Communications.

The Massachusetts Institute of Technology has named longtime technologist and entrepreneur Franklin Moss ’71 as director of its influential Media Lab. Moss, who received his bachelor's in mechanical and aerospace engineering from Princeton, was most recently the founder of Infinity Pharmaceuticals, which seeks technological approaches to cancer treatments. He has led several computer and software companies, including Stellar Computer, Bowstreet and Tivoli Systems. He is currently a member of the Princeton Engineering Leadership Council.

Yahoo! Inc. has appointed Ronald Brachman ’76 to be vice president of its worldwide research operations at its newly created research center in New York City. Brachman, who earned a B.S.E. in electrical engineering from Princeton and a Ph.D. from Harvard, was previously at the U.S. Defense Advanced Research Projects Agency (DARPA) and at AT&T Labs.

The University of Pretoria in South Africa has selected Wesley Harris *68 to receive an honorary doctorate to honor him as “an exemplary scholar and role model for fellow Americans as well as the youth in South Africa.” Harris, head of the department of aeronautics and astronautics at the Massachusetts Institute of Technology, is chair of the Princeton Engineering Leadership Council.

Claudio Bruno ’76 is the author with Paul Czysz of “Future Spacecraft Propulsion Systems,” a textbook published in February by Springer-Praxis. Bruno is a professor of mechanics and aeronautics at the University of Rome.
Norman Kurtz ’58 honored with scholarship and innovation funds

When friends and family of Norman Kurtz ’58 gathered in New York in January, they did just the things for which they so fondly remember him: They celebrated their love and friendship and created lasting ways to help other people.

Kurtz, who died unexpectedly of a heart attack in May 2005 at age 69, founded a premier international engineering firm, helped create some of the world’s largest and most advanced buildings, pioneered the field of sustainable engineering and taught architecture at Princeton, all while leading a rich family life, playing competitive tennis, skiing avidly, and being a friend and mentor to scores of people.

“Norman’s love for life was contagious,” long-time friend and business associate Gene Kohn said in a memorial video that was shown at the gathering. “He packed so much into life, it seemed as though he lived the life of three people.”

Remembering the many facets of Kurtz’s life, his family, friends and associates gathered at New York’s Center for Architecture and announced several gifts to Princeton that honor Kurtz’s commitment to his profession and to helping future generations. Michael Celia ’83, chair of Princeton’s Department of Civil and Environmental Engineering, described the gifts:

• Family and friends created the Norman D. Kurtz ’58 Scholarship, which will enable students from all backgrounds to receive the benefits of a Princeton Engineering education. “Norm deeply valued his own education and recognized the importance of helping others gain access to great education,” Celia said. “He felt strongly that such access is critical to the future of the architecture and engineering industries.”

• The firm Kurtz co-founded, Flack and Kurtz, established the Norman D. Kurtz ’58 Fund for Innovation in Engineering Education, which will support students who are engaged in real-world engineering projects outside the classroom and outside the country. “This fund reflects Norm’s love of work inside and outside the classroom and his desire to prepare and inspire future generations of engineers,” Celia said.

• The Princeton School of Engineering and the Center for Architecture in New York created the Norman D. Kurtz Memorial Lecture Series, which will include speakers who share Kurtz’s interests in engineering, architecture, sustainability and the improvement of the built environment.

“He loved Princeton,” said Kurtz’s wife of 40 years, Helen (Honey) Kurtz. “It was really very important to him. It gave him the background and tools to go out in the world. And he could never have gone to Princeton without a scholarship.” One of the Kurtz’s daughters, Lori, graduated from Princeton in 1989. Kurtz also is survived by another daughter, Stephanie.

He graduated magna cum laude, Phi Beta Kappa with a bachelor’s degree in mechanical engineering in 1958. He earned a master’s degree from Stanford, and by 1969 he and partner Peter Flack had founded their own firm, which grew over the decades to have more than 350 people and offices around the world. Among many projects, Flack and Kurtz provided engineering services for the construction of Malaysia’s Petronas Towers, the tallest buildings in the world. For 22 years, he served as an adjunct professor at Princeton’s School of Architecture.

“He had a real presence,” Mrs. Kurtz said. “But for all his accomplishments, he was very modest. He was just a very talented guy with a great sense of humor.” Even at the gathering eight months after his death, it was hard to grasp that Norman was not physically in the room, she said.

Friends recounted how Kurtz took every opportunity to build relationships and help people, whether in business, sports or personal life.

“He was just a delightful guy,” said Bruce Fowle, founder of the architecture firm FXFowle and frequent tennis partner with Kurtz. “He would play to your game. He would make sure you were playing as well as you possibly could. He was the same way with architecture. He wanted to make sure you were doing the best you could.” —SS
New building will bridge engineering and social sciences

Even with construction a year away, anticipation is rising among the future occupants of a new building that will be constructed midway between the engineering quadrangle and the University’s social sciences neighborhood.

Members of the Department of Operations Research and Financial Engineering (ORFE) and the Center for Information Technology Policy (ITP) are working with University administrators and architect Frederick Fisher to finalize plans for the new building, shown here in computer renderings.

The three-story building will encompass more than 45,000 square feet and provide an atrium, offices, classrooms and a lecture hall. It will be located at the intersection of Charlton Street and Shapiro Walk, across from the Friend Center and next to Mudd Library. Its location reflects the strong ties that the ORFE department and the ITP center have with economists, policy-makers and other social scientists.

“The building plans look terrific,” said Robert Vanderbei, professor and chair of operations research and financial engineering. “All of us in the department are thrilled with the commitment the University has made to this important new area of engineering that we are pioneering. The building’s location and Fred Fisher’s design are going to work beautifully to create a great working space and foster connections between engineering and the social sciences. We can’t wait to move in.”

Construction is due to begin in the spring of 2007 and to be completed in the summer of 2008.