Forefront

COLLEGE OF ENGINEERING UNIVERSITY OF CALIFORNIA, BERKELEY

spring 2011

The gift of gait

Robotic exoskeleton restores mobility to paraplegics

Do the right thing

BART NAGEL

When confronted with a problem, engineers are taught to ask, "What can we do?" We are very good at combining scientific and mathematical knowledge with creativity to invent solutions that will change our world.

But I believe we should also ask ourselves, "What *should* we do?" every time we tackle an engineering challenge. Whether we are building a dam, designing a drug or making online business more secure, we must anticipate and address the ethical questions that inevitably arise. The answers to these questions are rarely straightforward.

For example, let's consider the case of a civil engineer who is asked to evaluate bids to repair a badly damaged bridge. One bid promises to reopen the bridge much more quickly than competing bids, with significant ramifications for the local economy. Yet this bid proposes to use a controversial, not thoroughly tested technique. What should the engineer recommend to her superiors?

In another case, a team of engineering students is working on a technology that could boost the capacity of mobile communications in an underdeveloped area, opening up possibilities for new businesses and more jobs. As living standards rise above poverty levels, will the region's natural resources be overtaxed? How do engineers, with their powers of calculation, evaluate the competing merits of prosperity and sustainability? Should engineers even be held responsible for deciding on such policy issues?

Talking about problems like these can be frustrating for engineering students. As they sort through the nuances of ethical thought and action, they may encounter unfamiliar degrees of ambiguity and disagreement. Such absence of clarity and consensus can be challenging for anyone used to letting the facts speak for themselves.

Yet I, for one, have become impatient at hearing that engineers lack the broad perspective needed to have a voice when big decisions must be made. On the contrary, our world confronts us with problems that can be solved only by those with a deep understanding of technology—as long as it is matched with the ability to assess its impact on society.

A recent gift from alumnus Warren Minner (B.S.'51 CE) is launching the newest initiative in the college's ongoing work to build the capacity of engineering leaders. The Minner Endowment for Engineering Ethics and Professional/Social Responsibility will support efforts to teach students the fundamentals of ethical conduct that can guide them in their professional and research careers. David Dornfeld, professor and chair of mechanical engineering, has agreed to hold the first faculty directorship of the Minner program, which will be administered through our Fung Institute for Engineering Leadership.

Making sure our engineers are conversant with ethical considerations is ever more important as we pursue innovation in emerging areas such as nanotechnology, biofuels and next-generation nuclear power, brain-computer interfaces and information privacy. I am grateful to Warren Minner and to many others who are providing support, advocacy and guidance as we meet our imperative to educate the citizen engineer.

—**S. SHANKAR SASTRY**
Dean & Roy W. Carlson Professor of Engineering
Director, Blum Center for Developing Economies

Forefront is published twice yearly to showcase the excellence of Berkeley Engineering faculty, alumni and students and bring their work to life for a broad engineering audience through news and research, profiles and current issues and events.

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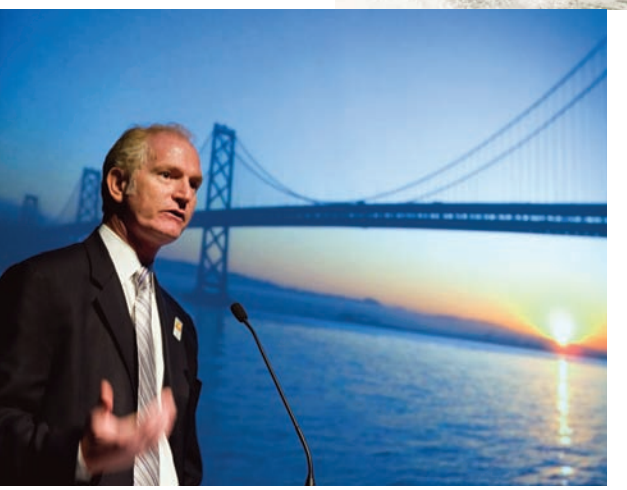

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On the cover
Read the story on page 8.

UC Berkeley student Austin Whitney, a paraplegic, walks aided by an exoskeleton that was developed by mechanical engineering professor Homayoon Kazerooni and his team of engineering students.

COVER PHOTO BY SARAH PEET

Letters
TO THE EDITOR

The rewards (or not) of engineering

I just finished reading your fall 2010 issue, which provided an expansive view of Berkeley Engineering. The only sour point was a letter complaining about the lack of engineering jobs, particularly for civil engineers. Although I do agree that we lack apprenticeships, I totally disagree about senior engineers not having rewarding careers. I have been lucky to be in the right place at the right time, with one interesting project leading to another.

In the 34 years since I left Berkeley (a choice I always prize), I have worked on projects both here and overseas ranging from urban renewal and transit to transmutation of spent nuclear fuel rods and automated factories. Two of my most fulfilling assignments, because they brought me back to engineering basics (i.e., identify the problem, develop a price-effective solution and fix the problem), were my assignments with FEMA. The first was an assignment in St. Bernard Parish (next to New Orleans's lower ninth ward) right after Katrina; the second was working with California state agencies like Parks and Recreation and Fish and Game on restoration following winter storms and floods.

I have also been fortunate to have mentored a number of young engineers and see them go on to challenging careers in engineering and management. With such an exceptionally rewarding career, I will NOT try to dissuade anyone from being an engineer or pursuing a career in civil engineering.

—**GERRY FINN** (B.S.'72, M.Eng.'76 CE)
Paso Robles, California
Project controls manager, Parsons Brinckerhoff

Tribute to a great engineer

The article in your last issue on the life of Harvey Ludwig was a tribute to a great man and a great supporter of Berkeley, but it didn't do justice to this great man. As a friend and colleague of Harvey's for the past 50 years, I can tell you that he was a committed environmentalist, but one who had a realistic view of both the needs and the methods of accomplishment. He had a clear vision of exactly what was needed in the emerging nations in regard to environmental issues, and he adjusted his recommendations to social and economic realities.

We communicated almost daily over the past 20 years (thanks to the Internet) and were in touch up to his last days. Even after returning home from his hospital stay and a few days before his passing we were discussing world events, and his comments were as sharp and pointed as ever.

I am one of the editors of the book that you referenced at the end of the article. Harvey was so pleased to be invited to contribute a chapter. He was a great man, possibly one of the most brilliant people I have ever known.

—**FRANKLIN J. AGARDY** (M.S.'58, Ph.D.'63 CE)
Hillsborough, California
President, Forensic Management Associates

WE LOVE YOUR LETTERS!

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Engineering faculty recognized as top teachers

Berkeley faculty know their material. Yet to teach it so that students not only understand, but also find inspiration and wonder in it, takes special talent and dedication. In 2010, civil and environmental engineering professor Juan Pestana-Nascimento and associate professor Dan Klein of electrical engineering and computer sciences joined a rarefied circle of Berkeley educators when they became winners of the Berkeley Distinguished Teaching Award.


PEG SKORPINSKI

Dan Klein teaches several computer science classes, but he receives the most praise for his CS 188 class, Artificial Intelligence. Students routinely give Klein high scores on teaching evaluations. "Dan Klein single-handedly raises the standard of teaching at Berkeley," senior Jim Sproch says. "His lectures are second to none: entertaining, engaging and educational." Klein joined the Berkeley faculty in 2004.


PEG SKORPINSKI

Friendly, helpful, funny, passionate, enthusiastic, inspiring—those are some of the words students use to describe **Juan Pestana-Nascimento**. A member of the Berkeley faculty since 1994, Pestana-Nascimento teaches geotechnical engineering, geoenvironmental engineering and geomechanics, and says he works hard for that "ah-ha" moment: "When their eyes light up and you see their smiles, you know they've been let in on a secret. They're accomplices now in the subject. That's rewarding."

BY RACHEL SHAFER

Engineers respond to Japan quake and nuclear crisis

When a 9.0-magnitude earthquake hit the northeastern coast of Japan on March 11, two of the reactors at the Fukushima Daiichi power plant were severely damaged by the force of a huge tsunami wave propelled by the massive offshore temblor. The accident quickly escalated into a nuclear emergency as the overheated complex began leaking radiation and crews scrambled to stabilize the reactors.

Five days later, UC Berkeley engineers met as part of a faculty panel to discuss the catastrophic event. The roundtable discussion, "Japan's Aftermath: An Initial Assessment of the Nuclear Disaster in Japan," drew an audience that included journalists, members of the campus community and the public.

Comparisons to the 1986 nuclear disaster at Chernobyl in Russia came up repeatedly. The experts highlighted the many differences between Chernobyl and Fukushima Daiichi, including the decision by the Russian government to wait three days before admitting that there had been a reactor failure.

AARON WALBURG

Radiation from a tsunami-crippled nuclear power plant in Japan does not pose a public safety risk to people outside of the disaster area, engineers told an overflow audience of about 100 people on March 16. Panelists explained that any levels of airborne radioactivity would be well within safe limits because radiation doses go down exponentially with distance from the source.

The panelists said that the Fukushima Daiichi accident highlights the complexity of nuclear power development, and noted that other countries, including China and France, are continuing to construct or operate nuclear power plants.

"We need energy. Every source has risks associated with it," said panelist Joonhong Ahn, professor of nuclear engineering. "If we do nuclear, we need deep international collaboration and discussion."

Joining Ahn on the panel were professors Jasmina Vujic and Peter Hosemann of nuclear engineering, Bozidar Stojadinovic of civil and environmental engineering and Dana Buntrock of architecture, as well as visiting professor Shinya Nagasaki from the University of Tokyo. Berkeley's nuclear engineering department is maintaining coverage of Japan's nuclear crisis at **www.nuc.berkeley.edu.**

BY KATE RIX


CELESTE LANE

Blum Hall opens on north side

With campus and national dignitaries on hand, the doors of Richard C. Blum Hall officially opened on October 8, 2010. It was a big occasion to celebrate what one project architect called a "little jewel box" of a building, small in scale but grand in its historic origins and its lofty goals.

Blum Hall now combines a lovingly restored Naval Architecture Building with an all-new wing in neo-Craftsman style to provide 22,000 square feet of space. The building houses the Blum Center for Developing Economies, which unites multiple disciplines—including engineering, business, energy and resources, public health, law and environmental design—and offers a rotating portfolio of classes designed to give students practical skills to target poverty in the world's poorest regions and populations.

Faculty/student research teams are now working to deliver safe water and sanitation systems in eight countries, implement new mobile technologies and services throughout Africa and Asia and provide energy-efficient technologies around the world.

In addition, Blum Hall houses the Coleman Fung Institute for Engineering Leadership, a new program that is leading the launch of a professional master's degree (see "Engineering Matters," p. 20) beginning next fall.

BY PATTI MEAGHER

Students have big ideas for improving water service

In the south India city of Hubli, turning on the tap is no easy task. Residents frequently skip work, postpone errands or keep children home from school in anticipation of the precious—but notoriously unreliable—arrival of water along urban pipelines. Missing a delivery can translate into days without household water.

"Literally, people wait around their house until the water comes on," says Anu Sridharan (B.S.'09, M.S.'10 CEE). "We've met people who've missed weddings, funerals and meetings."

Sridharan is part of a Berkeley-based student team pursuing a novel—but surprisingly simple—fix to what is a common occurrence in the developing world. Their project, called NextDrop, deploys ubiquitous mobile phones to alert residents when water is flowing in a neighborhood.

Mobile phones "are everywhere," explains Emily Kumpel, a doctoral student in civil and environmental engineering and NextDrop team member. "They're a very easy way to get information to people."

NextDrop, a first-place co-winner in UC Berkeley's 2010 Big Ideas competition, partnered with a local non-governmental organization last summer to begin a pilot study of some 200 households in Hubli.

The students recruited residents to form a mobile phone network in which participants called NextDrop when water arrived in their neighborhood. Once the call was received, NextDrop verified the information by contacting two other households, then generated cell phone messages to all participants served by the same water valve.

The team is also partnering with the local water board to exchange information about water deliveries. NextDrop may charge a nominal monthly fee for water notification service and is already awarding micropayments to customers who are the first to alert them to water availability. By relying on such crowdsourcing, the students expect to keep charges low.

For the NextDrop team, whose members include graduate students from Berkeley's School of Information and Goldman School of Public Policy as well as Stanford's M.B.A. program, the project's stakes are big. "It's just mind blowing to me that people don't have access to this basic need," says Sridharan. "It's just a matter of closing an information gap."

See more at **nextdrop.org**

BY ABBY COHN

COURTESY NEXTDROP

NOT A DROP TO DRINK: NextDrop could be a useful service in an estimated 90 percent of the cities in South Asia and a third of the cities in Latin America and Africa, where water systems are unpredictable and intermittent.

WORDS OF ENCOURAGEMENT: Engineering undergraduates Irina Badulescu (left), Wintana Alem (center) and Gary Ong (right) enjoy a panel discussion at Berkeley's first-ever LeaderShape Institute.

Bootcamp for leaders

They slept in yurts and went six days with virtually no cell phones or Internet service. But for 59 Berkeley Engineering undergraduates, spending their semester break at a woodsy Sonoma County retreat was the journey of a lifetime.

The students were participants in Berkeley Engineering's first-ever LeaderShape Institute, a national program that trains young people to lead with integrity and make significant contributions to better the world. They returned to Berkeley focused, energized—and ready to take on new challenges.

Held outside the town of Occidental, the event emphasized team-building and self-discovery. Students were organized in small groups called "family clusters." They navigated a ropes course, charted their visions for a brighter future and grappled with weighty ethical issues. At a panel discussion, business and community leaders shared their personal stories.

The undergraduates came from nearly every engineering major as well as diverse ethnic and personal backgrounds. Many were first-generation, low-income students. The program was funded by a grant from Raymond Yan (B.S.'74 ME), his wife, Eunice (B.A.'77 CS), and their RECARE Foundation.

LeaderShape is one of several initiatives organized by the recently expanded Engineering Student Services (ESS) to strengthen academic and professional advising while enhancing the undergraduate engineering experience. "A healthy disregard for the impossible will lead to new engineering solutions for the problems we're experiencing today and the problems we'll experience in the future," says Dale Masterson, director of ESS and coordinator of the LeaderShape program.

See more at **www.leadershape.org**

BY ABBY COHN

NEW SINGAPORE RESEARCH CENTER LAUNCHED

When it comes to reducing our carbon footprint, we can't overlook the importance of improving energy efficiency in our buildings. In the United States, 40 percent of the energy consumed is in buildings; in equatorial Singapore, that number jumps to 50 percent.

To address this global problem, the College of Engineering has established a new center for research, graduate education and innovation at Singapore's campus for research and technology. Known as the Berkeley Education Alliance for Research in Singapore, the center brings together top faculty and researchers from UC Berkeley and Lawrence Berkeley National Laboratory to engage in a major research collaboration with Singapore's National Research Foundation and Nanyang Technical University.

The first core research project, Building Efficiency and Sustainability in the Tropics (BEST), focuses on improving energy efficiency in tropical buildings. The program aims to cut energy usage for new buildings by 80 percent and existing structures by 50 percent. Costas Spanos, professor and department chair for electrical engineering and computer sciences, is leading the effort.

"Dramatically improving the energy efficiency of buildings has the potential of changing the dynamics of global warming," he says. "The BEST collaboration represents a nearly ideal ecosystem of resources and opportunities for creating and transferring some revolutionary ideas into the marketplace."

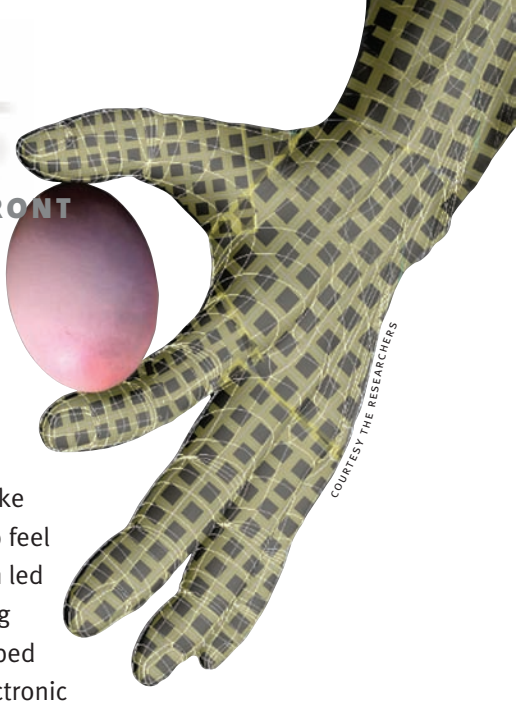
ChemE changes its name: UC Berkeley's Department of Chemical Engineering has been renamed the Department of Chemical and Biochemical Engineering, effective July 1, 2010. The new identity recognizes the department's substantial research and teaching in biochemical and biomedical engineering, biotechnology and synthetic biology.

"Trends in chemical engineering technology and the significant growth in biotech job markets over the past two decades affirm the important role biology plays in chemical engineering," said department chair Jeff Reimer. "The department wants to signal to applicants and to the general public that [it] is the nexus for research and teaching in the industrial applications of biology."

Breakthroughs

BERKELEY RESEARCH AT THE ENGINEERING FOREFRONT

MORE BREAKTHROUGHS **coe.berkeley.edu/news-center**



COURTESY THE RESEARCHERS

THIN-SKINNED

Imagine a material that functions like human skin, including the ability to feel and touch objects. A research team led by Ali Javey of electrical engineering and computer sciences has developed just that—a pressure-sensitive electronic material made from semiconductor nanowires. The artificial skin, or "e-skin," is the first such material made out of inorganic single crystalline semiconductors. The e-skin may help overcome a key challenge in robotics: adjusting the amount of force needed to hold and manipulate a wide range of objects. Researchers hope that, with advanced study and development, e-skin might eventually help restore the sense of touch to patients with prosthetic limbs.

http://newscenter.berkeley.edu/2010/09/12/eskin/

BART NAGEL

Small as a Dot

Move over, Jennifer Aniston. Dot, a 0.35-inch-tall figurine, just became the star of the world's smallest stop-motion video. Animators at the United Kingdom studio Aardman filmed her adventures with a Nokia N8 smartphone and a CellScope, an invention of bioengineering professor Daniel Fletcher and his students. The CellScope is a device that turns the camera of a standard cell phone into a diagnostic-quality microscope with a magnification of 5x-50x. In addition to recording the travels of a miniature movie star, the CellScope is designed to allow health workers in the field to capture and transmit images of disease agents, such as those causing malaria and tuberculosis, and analyze blood samples in real time.

www.youtube.com/watch?v=CD7eagLl5c4

COURTESY AARDMAN ANIMATIONS

Time is money

Anyone who has experienced a flight delay knows that it can not only be boring, but also expensive. A study led by Mark Hansen, civil and environmental engineering professor, backs that up. The report analyzed flight delay data from 2007 to calculate the economic impact on both airlines and passengers—taking into account lost passenger time, cancellations and missed connections, and accommodation expenses—and found that domestic flight delays actually put a whopping $32.9 billion dent in the U.S. economy. About half of that cost was borne by airline passengers.

http://innovations.coe.berkeley.edu/vol4-issue9-nov10/flightdelays

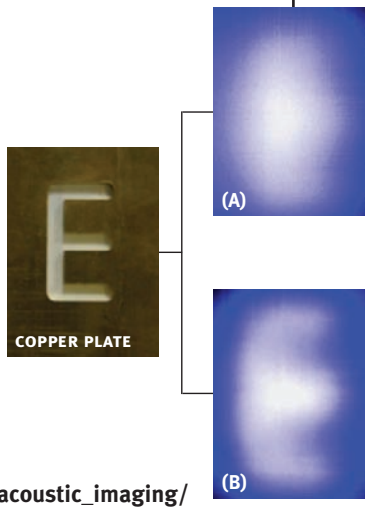
I GOT RHYTHM

As it turns out, rhythm helps the brain complete complex tasks. Until now, neuroscientists had not fully understood how neuron groups in different regions of the brain first linked together to work in concert. A study by UC Berkeley researchers, led by Jose Carmena, assistant professor of electrical engineering and computer sciences, shows that neuronal oscillations, or rhythms, organize the activity of individual neurons into larger functional groups. When neurons spread over the brain are tuned in to a certain pattern of electrical activity at a specific frequency, they can act together whenever the activity pattern occurs, according to first author Ryan Canolty, a postdoctoral fellow. The findings may eventually improve the performance of brain-machine interfaces and lead to new strategies for regulating dysfunctional brain networks through electrical stimulation.

www.sciencedaily.com/releases/2010/09/100920151806.htm

In the clear

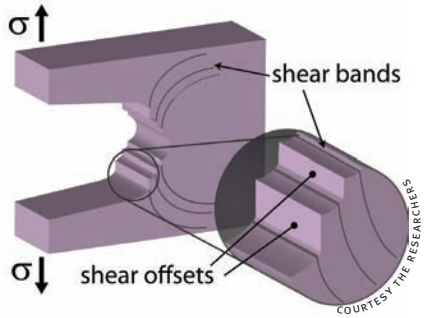
Is that a boy—or a girl? Expectant parents viewing an ultrasound are all too familiar with the fuzzy quality of its images. Scientists at the Center for Scalable and Integrated Nanomanufacturing, working with physicists at Universidad Autónoma de Madrid in Spain, have come up with a way to improve the resolution of ultrasound imaging. The team created a three-dimensional holey-structured metamaterial that can capture and transmit the evanescent waves bouncing off an object. Using the evanescent waves, the researchers could reconstruct detail as small as one-fiftieth of the wavelength of the sound waves, making super-resolution acoustic imaging possible. As shown here, a typical sonographic image of the letter E reveals no detail (A), but using the metamaterial, sufficient detail can be obtained to identify the letter (B).



COURTESY THE RESEARCHERS

http://newscenter.berkeley.edu/2010/11/05/metamaterials_acoustic_imaging/

A MIGHTY GLASS



COURTESY THE RESEARCHERS

The man of steel might need to rethink his moniker. Researchers at Lawrence Berkeley National Laboratory have collaborated with scientists at the California Institute of Technology to develop a new type of metallic glass, which has proven to be stronger and tougher than any known material—even steel. The damage-tolerant glass is a microalloy featuring palladium, a metal with a high "bulk-to-shear" stiffness ratio that offsets the natural fragility of glass. Materials scientist Robert Ritchie said the results came after researchers adopted a new strategy to fabricate the glass, and he believes they will develop even stronger versions in the future.

www.nature.com/nmat/journal/v10/n2/full/nmat2930.html

The gift of gait

Robotic exoskeleton restores mobility to paraplegics

BY ABBY COHN | PHOTOS BY SARAH PEET

THE "A" TEAM: (L to R) Homayoon Kazerooni, Austin Whitney, Jason Reid, Michael McKinley and Wayne Tung with their robotic exoskeleton, known as the Austin Project.

In a research lab deep inside Etcheverry Hall, 22-year-old Austin Whitney straps himself into a robotic suit and achieves the near impossible. Paralyzed from the waist down in a 2007 car accident, Whitney is learning to walk again.

"Are we all powered up?" the Berkeley student asks as the experimental machine lifts him upright and guides his legs through a series of paces across the floor of the Berkeley Robotics and Human Engineering Laboratory. With the device's help, Whitney stood up for his birthday last November and took his first steps as a paraplegic in January, barely two months later.

"There are millions of people around the world who would give anything to be where I am," says the tousled-hair Southern Californian, who graduates this May with a double major in political science and history.

If a Berkeley team led by mechanical engineering professor Homayoon Kazerooni is successful, paraplegics and many others who use wheelchairs may soon be exactly where Whitney is—regaining some ability to stand, walk and live more independent lives. "That's a remarkable achievement for someone in a wheelchair," Kazerooni says.

Still under development, the effort is called the Austin Project in honor of its first human test subject. Austin's researchers have a bold mission: to build a reliable, inexpensive walking machine for everyday personal use. The notion of limiting people to wheelchairs or crutches "is completely unacceptable with the existing technology we have," asserts Kazerooni, director of the robotics lab and a leading expert in "exoskeletons," or wearable robotic devices that enhance strength and improve mobility.

Kazerooni and his graduate student researchers envision robotic legs costing no more than $15,000. At that price, Kazerooni says, they would be roughly equivalent to a motorized wheelchair and within financial reach of many spinal cord injury patients, stroke victims and others with lower-body mobility disorders. The National Science Foundation is funding their work.

"The need is great," says Kazerooni. "What we wanted to see is if there is any way to make machines for people with mobility disorders at a cost far lower than anything [that's been] done before."

A handful of futuristic exoskeletons for paraplegics have been unveiled recently, but Kazerooni estimates their cost at around $100,000 and says they are intended for rehabilitation centers and other institutions rather than for in-home use.

One device, called eLEGS, was hailed as a top invention of 2010 by *CNN* and *Wired* and *TIME* magazines. An artificially intelligent exoskeleton that enables wheelchair users to stand and walk, eLEGS was introduced in October by Berkeley Bionics, a company cofounded by Kazerooni. Kazerooni and two students were developers of the system's controller and human-machine interface. Another exoskeleton, the Israeli-built ReWalk, created a stir when it was featured in a December 2010 television episode of *Glee*. The companies behind both inventions say they are working on versions for personal use.

Kazerooni has long been interested in intelligent devices that assist but don't supplant humans. He previously designed robotic systems for workers who move heavy objects in distribution centers and factories. One of his breakthrough inventions, the Berkeley Lower Extremity Exoskeleton (BLEEX), is a self-powered machine with metal leg braces, a power unit and backpack that enables users to carry heavy loads with ease. Its successor, the Human Universal Load Carrier (HULC), was developed in 2008 and allows people to carry up to 200 pounds. Berkeley Bionics and Lockheed Martin later co-developed a program to fortify HULC for various military and industrial applications. HULC is currently marketed by Lockheed Martin.

Harnessing the potential of robotics to benefit disabled communities has become a driving passion for Kazerooni. "I'm pushing this to another step," says Kazerooni, who would like to complete Austin by mid- or late

2012. If the project proves the feasibility of lower-cost technology, he hopes investors will be interested enough to commercialize it for mass production.

"MAKE THE HONDA, NOT THE PORSCHE"

Austin has a deliberately stripped-down design. It consists of prosthetic steel legs and a backpack-like harness that holds a computer, two small motors and a rechargeable battery capable of running for six to eight hours. "The analogy Kaz [Kazerooni] likes to use is we want to make the Honda, not the Porsche," says Wayne Tung (B.S.'08 ME, MSE, M.S.'09 ME), a 25-year-old graduate student who joined the Austin project at its start two years ago and has stayed on to earn his doctorate because of it.

Built with many off-the-shelf parts, Austin has a limited range of motions. It allows users to stand, walk forward, stop and sit. But Kazerooni believes those few simple maneuvers will be game-changing. "Things don't have to be really fancy. They don't have to dance. They don't have to walk backwards. They don't have to climb ladders. What is important to millions of people is to be upright, mobile and independent," he says.

Dr. Akshat Shah, chief of spinal cord and orthopedic rehabilitation at Santa Clara Valley Medical Center in San Jose, recently began testing an eLEGS at the hospital's rehabilitation unit and has been collaborating with Kazerooni and his Berkeley Engineering lab on Austin. "The technology is very close," he says of these devices. "We're in the beginning of a huge leap forward, a huge paradigm change."

For paralyzed patients, the prospect of standing and walking once again "provides hope," Shah says. "Just the thought of walking down the aisle to get married, reaching up to a top cupboard, walking outside on a beautiful day. This is part of their lives they thought they'd lost."

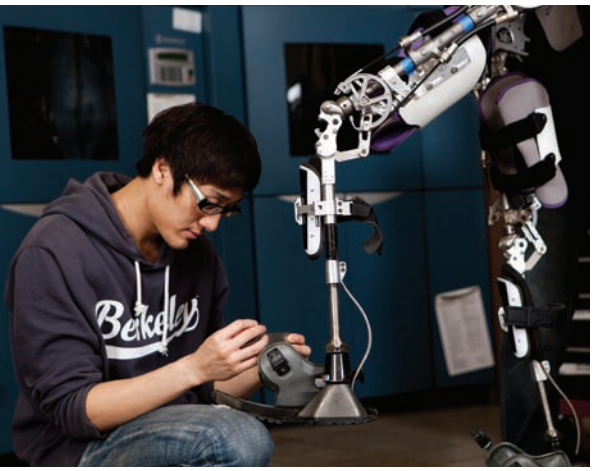
Along with that regained mobility, Austin and machines like it could help patients avoid involuntary muscle contractions known as spasticity, bed sores and the loss of bone density.

To build an inexpensive yet reliable product, the engineers are taking an unconventional approach: less-is-more. "As an engineer, always adding is easier than subtracting," says Kazerooni. Students are often taught to add extra electronics, aluminum or sensors to ensure the integrity of their projects. Austin is different. "My philosophy is to take out while keeping the performance; our aggressive cost targets dictate moving functionality from standard engineering to innovative designs and intelligent computation," Kazerooni says.

Achieving that simplicity is actually very challenging because an exoskeleton like Austin is inherently complex. It works through a delicate interplay of mechanical hardware, electronics, computer software and human-machine interface.

While Austin remains a project in the works, the engineers say they have devised a number of creative responses to engineering challenges. The machine has been programmed, for instance, to work off a basic $20 or $40 computer rather than a more sophisticated $600 model. Instead of relying on actuators and other fancy electronics, the engineers made innovative use of hardware in the leg mechanism to produce a walking gait. Austin has a minimal number of sensors. To further cut costs and complexity, the metal hip and knee mechanisms on each leg are coupled and operate with a single motor.

The student researchers juggle work on the project with the demands of school, says Michael McKinley, a 23-year-old mechanical engineering doctoral student working on Austin's mechanical design and hardware system. "It comes down to cleverness. We're trying to design a device that does as much as possible with as little hardware as possible." Beyond reducing costs, a simpler design means less risk of system failures, the researchers say.



"IT COMES DOWN TO CLEVERNESS": *In designing the Austin exoskeleton (next page, right), the team tries to use as little hardware as possible. The process entails adjustments to the design (above), a series of discussions among team members (right) and testing by Whitney (next page, left).*

OPERATING INSTRUCTIONS

To operate the machine, a user or "pilot" like Whitney sits in a wheelchair and fastens himself into the exoskeleton with straps and clips at his shins, legs and midsection. He activates the machine wirelessly with a switch in either a walker or crutches. Each operation—standing, walking, stopping or sitting—is initiated by the computer, which in turn sends a signal to motors and gears. Whitney shifts his weight to help guide the machine through its maneuvers.

Whitney's pace is still slow and somewhat mechanical. But the researchers are optimistic they will achieve a brisker, more natural gait. They also predict that their finished product will be much lighter than Austin's current 50-pound weight.

To ensure his safety, Whitney often walks inside the lab with a tether linked to a ceiling-mounted beam. He must use a walker or crutches and is spotted by one or more of the graduate researchers when he leaves the lab.

"This device must be such that even if the wearer tries to fall, he can't," says Kazerooni. To that end, the machine's knees were redesigned this winter to ensure that they reliably locked whenever Whitney's legs shifted from a step to touching the ground.

The Austin project experiences ups and downs typical of most scientific research. There are constant modifications as the team spots problems and devises fixes. "We're moving forward," says Kazerooni, whose lab is already working on a next-generation prototype that could be worn under clothing.

Whitney is an integral part of the lab's effort. Only slightly younger than the graduate students themselves, he has put a human face on the project. He also has become both a colleague and a friend.

Whitney heard about the project from an acquaintance last summer. He signed on as a test subject soon afterward. "I'd been in a wheelchair three years when Professor Kaz said he wanted to get me walking again. The question isn't 'Why would I [want to get involved]?' The question is 'Why wouldn't I?'" Whitney recalls.

Whitney comes to the lab two or three times a week to test the device, providing an invaluable user's perspective. Without Whitney, "everything is kind of theoretical," says Jason Reid, a 27-year-old doctoral student in charge of Austin's control system. "All that theory doesn't mean anything until someone starts using the machine."

During their long hours in the lab, Whitney and the student researchers chat and listen to rock music. Their commitment to the mission is shared and deep. "I think we all live this project," says McKinley. "I know we all dream about solutions to problems."

Whitney's first steps in January were unforgettable. "He painted a picture for us far more beautiful than we thought," Kazerooni says.

Since that day, Whitney says he's become a changed person. "It taught me how careful you want to be with the word 'impossible.'"

"They don't have to walk backwards.
They don't have to climb ladders.
What is important to millions of people
is to be upright, mobile and independent."

Superstructure

Marwan Nader and the new Bay Bridge design

BY RACHEL SHAFER

HANGING BASKET: The Bay Bridge's new self-anchored suspension segment, planned for completion in 2013, uses a single cable anchored into the deck and wrapped around the tower to create the compression needed to hold up the bridge. The design solves the problem of the bay's geology: mud so soft it behaves like Jell-O and makes anchoring traditional suspension cables into it difficult.

COURTESY CALTRANS

Rising

Marwan Nader was walking outside Davis Hall when the earthquake struck. He felt a jarring sensation, as if someone were trying to nudge him over. *Something significant has happened*, the graduate student thought. It was 5:04 p.m. on October 17, 1989. Reports trickled in—6.9 magnitude—and rumors quickly spread. The Bay Bridge had collapsed!

Actually, the San Francisco–Oakland Bay Bridge *hadn't* collapsed, everyone learned, but a 50-foot section of the upper deck had fallen onto the lower deck, crippling the eastern span that straddled Oakland and Yerba Buena Island. The entire bridge closed for a month.

Not long after the Loma Prieta quake struck, Nader gazed at the hole in the bridge as he stood a safe distance away, part of a Berkeley team inspecting the damage. Twenty-two years later, he's still standing on the bridge, so to speak. As lead design engineer of the self-anchored suspension (SAS) bridge, he is responsible for the standout architectural feature of the new portion of the bridge that will replace the old eastern span.

The new bridge is meant to do what the old one didn't: withstand a major Bay Area earthquake (7.0 or greater), sustain only limited damage and quickly admit emergency vehicles and traffic. It must deliver a performance to match its "lifeline" designation, adopted by the state legislature not long after Loma Prieta.

It's also a lifeline for Nader (M.S.'89, Ph.D.'92 CE) because he's bet his career on it. Beginning in 1997, when he first got involved in the bridge design, he's defended the sometimes controversial SAS plan; weathered waves of criticism and cost overruns; survived political tugs-of-war, delays and project kills; and still is working on it, adjusting the design to support the contractors as they erect the structure.

More than 20 years in the making, at an estimated total cost of $6.3 billion (the original 1997 estimate was $2.6 billion), the new eastern span bears the weightiest of expectations. For Bay Area cities, as dictated by the Metropolitan Transportation Commission (MTC)'s 1997 design criteria, it must be distinguished by a unique aesthetic, one that would match the beauty of the existing western span and the nearby Golden Gate Bridge. One easily identifiable on a tourist's postcard. For the public, it must prove a wise use of funds. And, most important for the 280,000 vehicles crossing the bridge each day, it must stand and deliver.

The whole project is ambitious, to put it mildly. The construction contract alone, worth $5.2 billion, is the largest public works contract in California history. When the bridge opens in 2013, it will be like nothing else in the world. "We are giving the community a safe structure," Nader says. "We are building a bridge for the future."

Under Construction

Nader's project will be the longest single-tower, self-anchored suspension bridge in the world. (But not the first. The first self-anchored suspension bridge was built in Germany during the early 1900s.)

100% PS&E

Once or twice a week, Nader drives from the construction worksite on the Oakland shoreline across the bridge to the San Francisco office of renowned structural engineering firm T.Y. Lin International, where he is vice president. "You have to keep your eye on the road, of course," he says, "but I can't help but glance over to see how things are going."

On the north side, two side-by-side elevated roadbeds—the 1.2 mile-long skyway portion of the span—curve gracefully toward Yerba Buena Island. Almost complete, the skyway stands in sharp contrast to the old double-decker cantilever span sheathed in gray steel, which, when it first opened in 1936, carried commuter trains as well as cars and trucks.

Farther along are inklings of the signature design, rising in an unusual asymmetry that departs from standard suspension bridge design. Among the features: a single, 525-foot tower comprising four separate, slender shafts (a first for suspension bridges) interconnected with shear link beams (another first) designed to absorb seismic movement and keep the tower elastic yet stiff and upright during an earthquake.

The SAS span, built with high-strength steel, will connect to the skyway via hinge pipe beams that expand and contract during seismic shaking, absorbing most of the energy and elastically transferring loads between the two different bridge segments. The tower and deck "float" around each other, unconnected. Although suspension cables appear to drape down from the tower, they are an illusion. Unlike the Golden Gate and other traditional suspension bridges—where separate cables are put into tension by the resistance of anchorages fastened into the earth on either end—here a single cable fastened to the east anchorage of the deck and looping around the west piers acts like a giant rubber band to put the span into compression.

Nader, a native of Beirut, Lebanon, has always loved big, bold structures, the Sears Towers and Golden Gates of the world. After graduating with a bachelor's in engineering from the American University of Beirut, he arrived at Berkeley for graduate studies in structural engineering. "Berkeley opened my eyes to the world," he recalls. "I saw what you can do to change things. That feeling was so powerful."

The Bay Area's seismic renown attracted his interest, and he was soon hard at work on a dissertation examining the seismic behavior of steel structures, advised by professors Abolhassan Astaneh, Stephen Mahin and Egor Popov, structural and earthquake experts in the civil engineering department.

Nader had planned to return home after graduation, but the Middle East didn't offer much in the way of seismic opportunity. When T.Y. Lin International recruited him to work on a seismic retrofit of the Golden Gate Bridge, he jumped at the opportunity and joined the firm in 1992.

(Structural engineering students continue to benefit from Berkeley Engineering's long association with T.Y. Lin International and its late founder, civil engineering professor T.Y. Lin, although Lin later sold the company. Last fall the T.Y. Lin Foundation and Lin's son, Paul (B.S.'64, M.S.'66 EECS), one of its directors, pledged a substantial new gift to the T.Y. Lin Fellowship in Structural Engineering, increasing the fund to more than $500,000 to support outstanding graduate students.)

The Bay Bridge remained a ticking time bomb. In the years after Loma Prieta, state transportation officials debated whether to retrofit or replace it. The western span could be retrofitted, Caltrans engineers determined. But after a lengthy economic and structural analysis, then-Gov. Pete Wilson in 1997 approved replacement of the eastern span, citing longevity of 100 years or more with a new structure as opposed to 30 with the existing span.

Caltrans entertained bids and by November had selected two semi-finalist designs from two separate teams in a joint venture between T.Y. Lin International and Moffat & Nichol Engineers to compete for the winning design.

Nader, 33 at the time, led the single-tower SAS team. The challenge? Marry the precise aesthetic specifications dictated by the MTC with the stringent seismic performance required by Caltrans. Specifically, find a way to stabilize a single tower in a major earthquake so it wouldn't snap off like a light pole. Remembering his Ph.D. adviser Egor Popov's research involving shear link beams in eccentric-braced building frames, Nader realized he could split the tower into four slender shafts and connect them up the height with two-meter-long shear links, maintaining a single tower look. Seismic performance analysis outcomes proved excellent.

Nader's team built a physical model and took it to the final competition in November 1998. The model looked gorgeous, Nader thought. He was on cloud nine when the single-tower SAS design won the contract. "Not only was my team's design selected," he says, "but I knew it was going to become a reality. It was a fantastic moment."

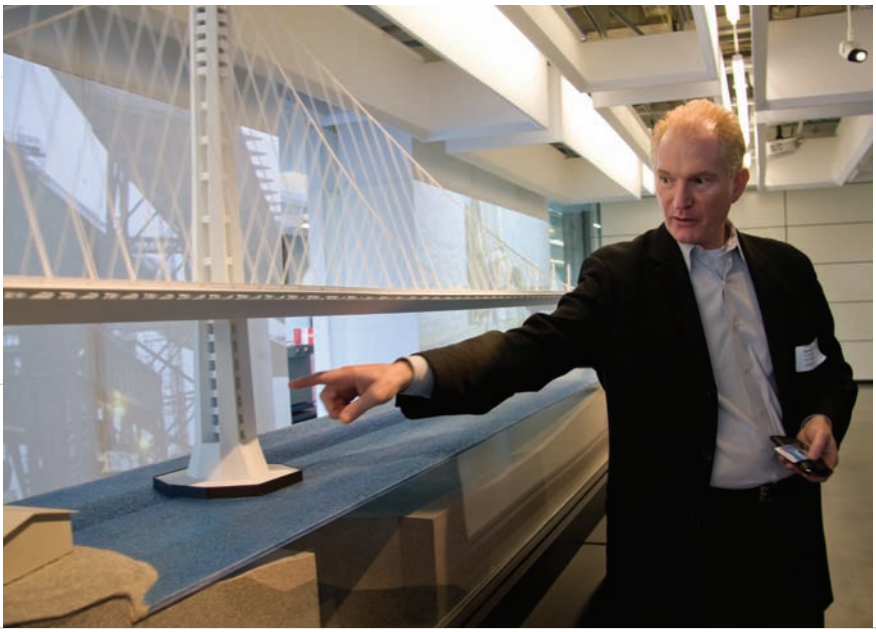
"A Piece of History"

T.Y. Lin International engineers from around the country moved to San Francisco to work on the project. In early 1999, Nader assembled his team to meet with Caltrans officials and agreed to deliver final plans by mid-2001. They logged 60- and 90-hour workweeks, sleeping in their offices and putting personal lives on hold.

But, outside of T.Y. Lin International, all did not proceed as planned. A political controversy erupted over the alignment of the new span. Questions over right-of-way access to Yerba Buena Island put the Navy in conflict with Caltrans. Oakland and San Francisco raised objections. A new element, a bike and pedestrian path, was studied, debated and incorporated. And critics turned up the volume, taking issue with the engineers' seismic analyses and raising concerns about the bridge's performance in a major earthquake.

Nader, for his part, remains confident in the bridge's seismic integrity. T.Y. Lin International used industry-standard ADINA general-purpose finite element software to run three different

COURTESY CALTRANS



SUSAN LOHWASSER

MODEL BRIDGE: Nader's seismic innovations for the span's single tower were inspired by a professor's research. Engineers and architects from around the world are eager to use the design for their own projects.

SUPPORT STRUCTURE: A segment of the tower is hoisted into place. SAS designs pose challenging construction problems. "If the deck is needed to hold the cable and the cable is needed to hold the deck, it's like the chicken and the egg. Which one do you build first?" Nader explains. The answer: a steel truss bridge—or falsework—to support the permanent bridge. Seen here underneath the roadbed, the falsework will be taken down after the cable is installed and bears the bridge load.

seismic performance analyses: time history, pushover and local detailed analyses. "This bridge has been scrutinized more than any other structure I've worked on," the long-time bridge engineer says. "The testing and performance are sound."

Nader's team delivered final plans on schedule and continued to tweak the design through more delays and setbacks. In 2004, when a single construction bid came in, escalating construction costs had pushed the price tag far too high. Nader stood silent as political controversy and public outrage temporarily halted the project again. Construction finally began in 2006, four years late.

"This project eats up human beings," says Brian Maroney, deputy director of the Toll Bridge Program at Caltrans, who has worked on the Bay Bridge upgrade since 1995. "A lot of people have fallen by the wayside. But Marwan Nader has taken a few hits and is not a quitter. He has done some great things for us. UC Berkeley has reason to be proud of him."

Nader is anticipating the day in 2013 when the project is finally finished. He's already working on new bridges in Africa and the Middle East but admits there will be a vacuum in his life after the new Bay Bridge span opens. For 14 years, he's poured himself into the design. How has he managed?

"Look at it," he says, pointing to a rendering that hangs in his Oakland office. "It's a piece of art. It will be there for my grandchildren to see, a piece of history. That's how I do it."

Class notes

Keep in touch by mailing your news and photos to *Forefront* Class Notes, UC Berkeley College of Engineering, 312 McLaughlin Hall #1704, Berkeley, CA 94720-1704. Or go to **coe.berkeley.edu/alumni/class-notes** and click on *"Submit a new Class Note."*

2000s

ALICE CHEN (B.S.'03 BioE)

just finished her Ph.D. at the Harvard-MIT joint program in health sciences and technology. She was recently awarded the grand prize and won $15,000 at the 2010 National Collegiate Inventors Competition in Washington, D.C., for her work in humanizing mice with tissue-engineered livers.

DAVID ULRICK FANFAN (M.S.'01 CEE) writes, "After obtaining professional engineering licenses in California and New York and years of working on various projects throughout the United States, I expanded my geographic reach by enrolling at Hult International Business School's intense one-year MBA. There, I specialized in international business and had the opportunity to study in and experience Shanghai, China. During my two months in China, I couldn't help but observe the potential for seismic and environmental engineering opportunities that could help improve and modernize the infrastructure in Southeast Asia."

MANU BHASKAR GAUR (B.S.'09 CE) of New Delhi, India, is working at JPSI to help construct the $300-million Jaypee Circuit, India's first Formula 1 race track. He is handling a construction team of 3,500 people who are working to successfully complete the circuit by July of 2011. Gaur writes, "The best part of the job is doing something never done before in India...to face the daily challenges of organizing and utilizing so many effectively, and to receive Stanford University professors and students who came to the project last month in Berkeley t-shirts! Go Bears!"

EUGENE RYU KANEKO (B.S.'01 ME) of San Diego, California, writes, "I'm running an iPhone app development company and currently have a top-50 iPhone app and a top-10 iPad app in the photography category on iTunes."

MISHA LEYBOVICH (B.S.'05 Eng Physics) began working on his Ph.D. in aerospace engineering and technology policy at MIT this fall. Before settling into graduate school, he spent five months traveling through four continents and 20 countries. He also spent five months working at the Aerospace Corporation in El Segundo and worked as hiking director at Camp Oski at the Lair of the Golden Bear, UC Berkeley's family camp in the Stanislaus National Forest.

1990s

JASON BURKE (B.S.'95 Mineral Engineering) of Billings, Montana, writes, "While continuing to write a monthly column for *CE News*, my mining and management experience now helps me serve industrial clients in Canada and the U.S., specializing in operations improvement and business coaching. One of very few Cal alums in Montana, I am also a private pilot and freelance writer for local magazines."

BRYAN FOX (B.S.'96 ME) works for Capstone Turbine in Chatsworth, California, as a quality-control manager. He and his wife, Tammy, live in Agoura Hills.

MICHELLE KHINE (B.S.'99, M.S.'01 ME, Ph.D.'05 BioE) received a NIH Director's New Innovator Award for 2010, the largest and most prestigious grant awarded to junior investigators by the NIH. Khine is an assistant professor of biomedical engineering at UC Irvine.

1980s

MARK FREITAS (B.S.'80 CE) of Oakland, California, is now a principal engineer at GEI Consultants in Oakland.

ERIC A. NOVIKOFF (B.S.'84 EECS, M.Eng.'85 EE) of Mountain View, California, has been growing ENKI, a managed cloud computing company aimed at providing start-up SaaS (software-as-a-service) and growing companies with IT-as-a-service. In his new role as COO, he has been stretching his limits beyond engineering while enjoying being at the center of one of the hottest new technology trends. Eric can be reached at **eric@enki.co.**

SHUEN-SHIAN SHYU (M.S.'81 CEE) of Taipei, Taiwan, writes, "I am running James Shyu and Associates in Taipei. JSA is a consulting firm specializing in port and ocean engineering."

1970s

JAMES H. ALLEN (B.S.'72 EE) of Los Altos, California, is a technical writer at LensVector.

WEN-TSUEN CHEN (M.S.'73, Ph.D.'76 EECS) of Taiwan has

been named the recipient of the IEEE Computer Society's 2011 Taylor L. Booth Education Award in recognition of his contributions to computer science education in Taiwan and worldwide. A distinguished chair in National Tsing Hua University's computer science department, he has also served as department chairman, college dean and university president. Prior to founding the College of Electrical Engineering and Computer Science at the university, he served as a science and technology advisor to the Ministry of Education, where he helped establish the Taiwan Academic Network (TANet), the first Internet in Taiwan.

CHARLES LOUIS LEATH (M.Eng.'75 EECS) of Sunnyvale, California, retired from HP in 1999, where he had served as journal editor since 1987.

JOHN MOHNEY (M.S.'74 CE) of Portland, Oregon, writes, "I recently completed 10 years in the geotechnical group at PBS Engineering and Environmental in the Vancouver, Washington, office."

1960s

JOHN R. BISSET JR. (M.S.'69 CE) of Princeton Junction, New Jersey, writes, "Forty-one-year career in the nuclear power industry. Still working at 65!"

JOHN M. GASTON (B.S.'65, M.S.'70 CE) of Lafayette, California, retired from his position as a consulting engineer.

ANTHONY JOHNSON (B.S.'60 IEOR) of Carmel, California, writes, "Finished teaching grad courses for Chapman University in Monterey. Still on six non-profit boards including Salvation Army, Leadership Monterey Peninsula and Association of the U.S. Army, and run service projects for Monterey Kiwanis. Miss the men's rooting section at warm football games in the fall! Go Bears!"

HANS W. KORVE (B.S.'66, M.S.'67 CE) of Napa, California, started a new career in construction and public-private partnerships with Dragados USA in 2009 after selling his traffic engineering company, Korve Engineering, to AECOM in 2000.

CHARLES MINNING (B.S.'65, M.S.'66, Ph.D.'73 ME)

of South Pasadena, California, writes, "After putting it off for way too long, I've decided to really retire. My last day as a JPL employee was December 28, 2010. I can now pursue some serious technical collaboration with the University of Texas at Arlington, restart myself as the family genealogist, restart my historical research on covered wagon trails and early post-Civil War conflicts between the Army and Native Americans, take some gourmet cooking classes and do some serious background reading on global warming/climate change."

EVERT C. NYGREN (B.S.'66 EECS) of Incline Village, Nevada, retired in 2003 as an engineering manager in the telecommunications satellite business and is enjoying living at Lake Tahoe with his wife, Joanie. He has become an avid hiker and backpacker.

Evert C. Nygren

She paints for power

There are lead-acid batteries for your car and nickel-cadmium ones for your Sony Walkman. Lithium-ion batteries juice your laptop, iPhone and your high-definition, DVR-enabled, hidden camera wristwatch.

What will power our next-generation gizmos? The microdevices, nanodevices and picodevices of the future? Our prediction: the Christine Ho battery.

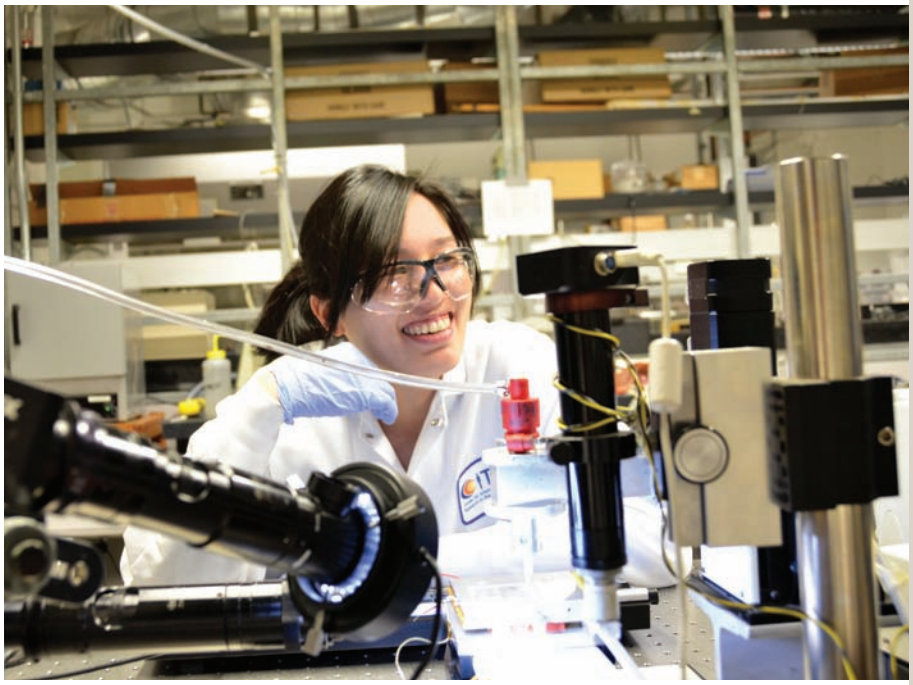
As an MSE graduate student, Ho (B.S.'05, M.S.'07, Ph.D.'10 MSE) developed a novel process of simultaneously fabricating and placing a tiny battery onto a one-square-centimeter RFID tag. The technology promises to not only power the smallest of smart devices, but also accelerate a variety of energy applications.

Before she could dream big, though, Ho faced a teeny-weeny problem. "The big challenge at the micro level lies not in the battery chemistry or material," Ho explains, "but in fabrication and integration with the device."

Because microdevices range from the size of a sugar cube to microscopic, swapping a battery in-and-out as you would for a remote control is next to impossible. So microbatteries, which are as thick as two human hairs (and getting smaller), must be powerful, long-lived and built in.

Advancing the work of previous students, Ho tackled the built-in component by means of a dispenser printer. She and fellow students "painted" layers of zinc electrode, gel electrolyte and manganese dioxide electrode, one on top of the other, in a precise spot on the RFID tag. Within an hour, the material "sandwich" was ready for use as a built-in, thin-film zinc polymer battery.

To get the needed precision, Ho's printer dispenses ink-like battery material via a syringe connected to a compressed air line and an electronic controller that tightly manipulates lateral and vertical movement. In comparison with other microbattery fabrication processes, the technique is fast, scalable and wastes little material. In other words, it suits manufacturing.



COURTESY CHRISTINE HO

***PRECISION MANUFACTURING:** Christine Ho with the printer dispenser tool she uses to fabricate microbatteries.*

Most important, the technique works. During initial testing, the batteries it produced demonstrated promising energy storage results, in both slow and fast discharge rates, and consistent performance over 100 cycles. Next, Ho will test the batteries at 500 to 1,000 cycles, the lifecycle range for consumer devices and car batteries. She is convinced her microtechnology will scale up for larger applications.

After graduating last year, Ho joined up with Brooks Kincaid (M.B.A.'11) to receive a mentorship with the Center for Entrepreneurship and Technology's Venture Lab program. The duo is working together to spinout this technology and printing paradigm through their new startup, Imprint Energy, Inc.

BY RACHEL SHAFER

ROGER POTASH (M.S.'66, Ph.D.'70 Naval Architecture) of Menlo Park, California, retired from Lockheed Martin's Advanced Technology Center in Palo Alto last year, having worked as a senior systems engineer developing space-based astronomy observatories and instruments for NASA. His interests include global climate change, having recently toured Denmark, to see how the Danes are developing a sustainable energy economy, and Greenland, to see firsthand the impacts of high atmospheric greenhouse gas levels on the Arctic environment and its Inuit inhabitants.

1950s

DICK FRADELLA (B.S.'57 EECS) of San Juan Capistrano, California, received an M.S. in electrical engineering from Caltech in 1960 and has spent a few decades as an aerospace engineer. He writes, "Over the past 35 years, working in my home office/lab, I developed a brushless regenerative DC motor, broad-speed-range DC generator and kinetic DC battery."

MOHAMMED "MO" S. GHAUSI (B.S.'56, M.S.'57, Ph.D.'60 EECS) of San Francisco, California, was dean of the College of Engineering at UC Davis from 1983 to 1996, and in 2009 became the third UC Davis engineering dean to have a building named after him. Ghausi has written or co-written more than 80 research papers and seven textbooks. He was named a fellow of the Institute of Electrical and Electronics Engineers in 1973, and among his other recognitions, received an IEEE Centennial Medal, a one-time honor on the occasion of its centennial in 1984.

NILAN LEE KINCAID (B.S.'54 EE) of Hawthorne, California, retired from Northrop Grumman in 1991.

CLEMENTS E . PAUSA (B.S.'53, M.S.'54 Metallurgy) of Atherton, California, retired in 2008 and is now engaged as a part-time consultant.

Wheels of change

More than nine million South African children walk to school every day. Three million walk for more than an hour, and in the rural countryside, some walk more than four hours.

In those outlying areas, many adults work as farm laborers; to find employment, they travel from farm to farm, trudging long distances. When families get sick, they rely on house calls from government health care workers, and the workers, too, must walk hours and hours to reach their patients.

"It's madness," says Louis de Waal (M.S.'72 CEE), who grew up in rural South Africa and spent his professional life designing and building thousands of kilometers of roads there.

Now retired, De Waal is on a mission to improve mobility for all South Africans, especially in rural areas. The goal, says the 73-year-old Cape Town resident, is to keep children in school and help adults reach work more easily, ultimately easing poverty and slowing the flood of people forced to move to urban areas for work.

But De Waal doesn't want to add more vehicles to roadways, grow public transportation or launch more infrastructure projects. His answer is the bicycle.

"Riding a bicycle is four times faster than walking and three times more efficient," the avid cyclist says. Bikes are cheap to operate and maintain, he adds. They improve one's health and don't burn fossil fuels or pollute the air.

In 2003, de Waal and a friend launched the nonprofit organization BEN, the Bicycling Empowerment Network. To date, BEN South Africa has imported more than 9,000 used bikes from donor organizations abroad. It fixes and distributes them at little or no cost to those in need.

The benefits are enormous. Health care workers on BEN bikes, for example, now see 500 to 550 patients a month (and spend more time with them), compared with the 100 to 200 patients they were typically able to serve via walking.

BEN also trains unemployed adults as bike mechanics and teaches them basic business management skills. It equips them with shipping containers, bicycles and tools in order to set them up as an independently run shop. Fifteen small businesses, or Bicycle Empowerment Centres, are now sprinkled throughout the Western Cape area.

Drawing on this formula, de Waal and BEN staffers have successfully grown the network beyond South Africa's borders, with sister organizations established in Namibia in 2005 and Botswana in 2009.

See more at **www.benbikes.org.za**

BY RACHEL SHAFER

COURTESY LOUIS DE WAAL

POWER OF THE PEDAL: Louis de Waal (in yellow) instructs government health care workers about bicycle maintenance and safety.

George C. Riek and friends

GEORGE C. RIEK (B.S.'57 CE) of Oregon City, Oregon, has had a 48-year career in public service and private practice, including working as research engineer for the Castro Valley Sanitary District, director of public works for the city of Livermore and vice president of CDM. He retired in 2005 and is now pursuing travel, photography and the arts.

NORMAN F. SCHNEIDEWIND (B.S.'51 EE) of Pebble Beach, California, is a professor of information sciences and director of the Software Metrics Lab at the Naval Postgraduate School. He is also a fellow of the Institute of Electrical and Electronics Engineers. In 2001, he received the Engineer of the Year award from the IEEE Reliability Society for his contributions to software reliability modeling and reliability leadership of key national programs, such as the space shuttle program.

BALRAJ SEHGAL (M.S.'57, Ph.D.'61 NE) of Stockholm, Sweden, writes, "I am currently emeritus professor of nuclear power safety at the Royal Institute of Technology in Stockholm, Sweden. I have just been awarded by American Nuclear Society the George Laurence Award for making outstanding

in memoriam

DONALD ALDEN (B.S.'47 CE) of Carmichael, California, died last summer.

CLIFFORD R. ALLEN (B.S.'48 ME) of Danville, California, died last June.

CHARLES A. DESOER of Berkeley, California, died in November at age 84. A professor emeritus of EECS, his work on circuits and control systems led to substantial advances in the aerospace and transportation industries. Desoer authored over 100 journal papers and wrote textbooks that are still considered the most authoritative references in circuits, systems and control.

PETER GIRARD (B.S.'40 ME) of La Mesa, California, died in February at age 92. A WWII Army Air Corps veteran, Girard made front page news and the cover of *Life* magazine in 1957 when he became the first person to successfully fly a revolutionary vertical takeoff jet.

ROBERT A. HOWEY (B.S.'65 ME) of Encinitas, California, died last June due to a degenerative brain disease known as frontotemporal dementia. He donated his brain to a study at UCSF to help find a cure for the disease.

GERALD "JERRY" JOHNSON (B.S.'59 ME) of Healdsburg, California, died in September. He was 79. An avid sailor and longtime volunteer at San Francisco's Maritime National Historic Park, Johnson led a three-decade-long engineering career that included work on missiles at the height of the Cold War, before leaving the aerospace industry out of concern for its involvement in military actions.

Think globally, surf locally

Lightly tanned and sporting a blond ponytail, Tobias Schultz (M.S.'10 ME) learned to surf in San Diego at age 14 and "has been hard at it ever since." But with the Schrödinger equation tattooed on his left arm, he is most definitely not your typical surfer dude.

The 26-year-old Santa Cruz native recently graduated with his mechanical engineering master's and a certificate in engineering and business for sustainability. Busy as a life-cycle assessor and one of the co-founders of the Sustainable Surfing Coalition, he is also the author of an extensive study on the carbon footprint of the surfing lifestyle, *Surfboard Cradle-to-Grave,* published in 2009.

COURTESY TOBIAS SCHULTZ

***HANG TEN:** Surfer and mechanical engineer Tobias Schultz loves "the feeling of flying across the water" and is working to make surfing greener.*

In his study, he calculated inputs and outputs of everything involved in manufacturing surfboards—from chemicals used in making foam blanks, to emissions from transportation, to toxic by-products. He compared data for two common board types, polyurethane and epoxy. He examined board lifetimes to determine whether the higher carbon footprint of epoxy is offset by its greater longevity.

Surprisingly, he found that fiberglass manufacture represents about 5 percent of a surfboard's carbon footprint, whereas resin and blank production make up about 70 percent. And that led him to another discovery.

It turned out that driving and flying to the surf make up 75 percent and 23 percent, respectively, of a typical surfer's annual carbon footprint, while surfboard manufacture accounts for just 2 percent.

To reduce surfing's carbon footprint, Schultz advises board producers to focus on resin and blank manufacture, a much larger slice of the pie chart. For surfers, he recommends living close to the beach, switching to fuel-efficient vehicles and buying from local shapers, the craftsmen who assemble surfboards.

Some of Schultz's opinions have raised the ire of some in the surfing community. But he believes that, viewed broadly, the environmental costs of surfing might be outweighed by its social and environmental benefits. These include health and fitness, strong social bonds, communion with nature and more.

See more at **sustainablesurfcoalition.org**

BY PATTI MEAGHER

pioneering contributions in nuclear safety."

WILLIAM J. SILVA (B.S.'59 CE) of Antioch, California, has retired as city engineer for San Leandro. He has also worked as a consulting engineer for Public Works Engineering Services.

1940s

DONALD CONE (B.S.'43, M.S.'51 EECS) of Los Osos, California, has been retired for 25 years.

JOHN MORRIS PARKER (B.S.'42 ME) of Palo Alto, California, writes, "I'm retired from United Airlines maintenance base at S.F. Airport. I was manager of the technical publication department."

MILTON SCHWARTZ (B.S.'47 CE) of Belmont, California, writes, "Now 90½ years old. My wife and I have football season tickets and go to all games."

THOMAS LEW STELZNER (B.A.S.'44, B.S.'47 ME) of Petaluma, California, has been retired for 25 years from Chevron, where he worked in Southern California, Alberta, the North Slope, Sudan and San Francisco.

JERROLD E. MARSDEN, professor emeritus of EECS at UC Berkeley, died in September at age 68. He did extensive research in the area of geometric mechanics and in dynamical systems and control theory. He was also one of the original founders in the early 1970s of reduction theory for mechanical systems with symmetry, which remains an active and much-studied area of research today.

CHARLES K.S. MILLER (B.S.'58 Eng Physics) of Newcastle Woontyne, England, died last June. He retired in 1987 as chief of the Electromagnetic Fields Division at the Natural Bureau of Standards in Boulder, Colorado.

WALTER ANDREW PARON (B.S.'50 Mining Eng) of Post Falls, Idaho, died last June.

HORACE PEASE PHILLIPS (B.S.'39 ME) of Whittier, California, died in January. He was a Navy lieutenant and the recipient of the Apollo Achievement Award from NASA for his work on Apollo 11.

FRED SAUER (B.S.'44, M.S.'47 ME) died last June. He joined the faculty as an assistant professor, then worked for the U.S. Forest Service, where he researched the effects of nuclear blasts over forested areas. He went on to perform studies on nuclear ground shock and cratering and wrote a history of nuclear airblast theory and experimentation. He and his wife endowed the Fred and Claire Sauer Chair in Environmental Engineering.

JACK R. SCARZELLA (B.S.'69 IEOR, M.B.A.'61) died in September. He worked for IBM for 21 years and was president of AMFAC Electric and Lynn Edwards Office. He started his own company in 1989, working until his retirement in 2007.

ROBERT STREICH (B.S.'29 ME) of Napa, California, died in February at age 105. He worked for RCA Communications at the Pt. Reyes Receiving Station and was later transferred to New York City, where he worked until his retirement in 1963.

RAY J. WINGER JR. (M.S.'49 CE) died last April in Wheat Ridge, Colorado, at age 91. He worked for the Bureau of Reclamation, developing engineering practices used in the drainage of irrigated land. In retirement, he served the city of Wheat Ridge as mayor and member of the planning commission.

Engineering matters

PROFESSIONAL MASTER'S OPENS FALL 2011

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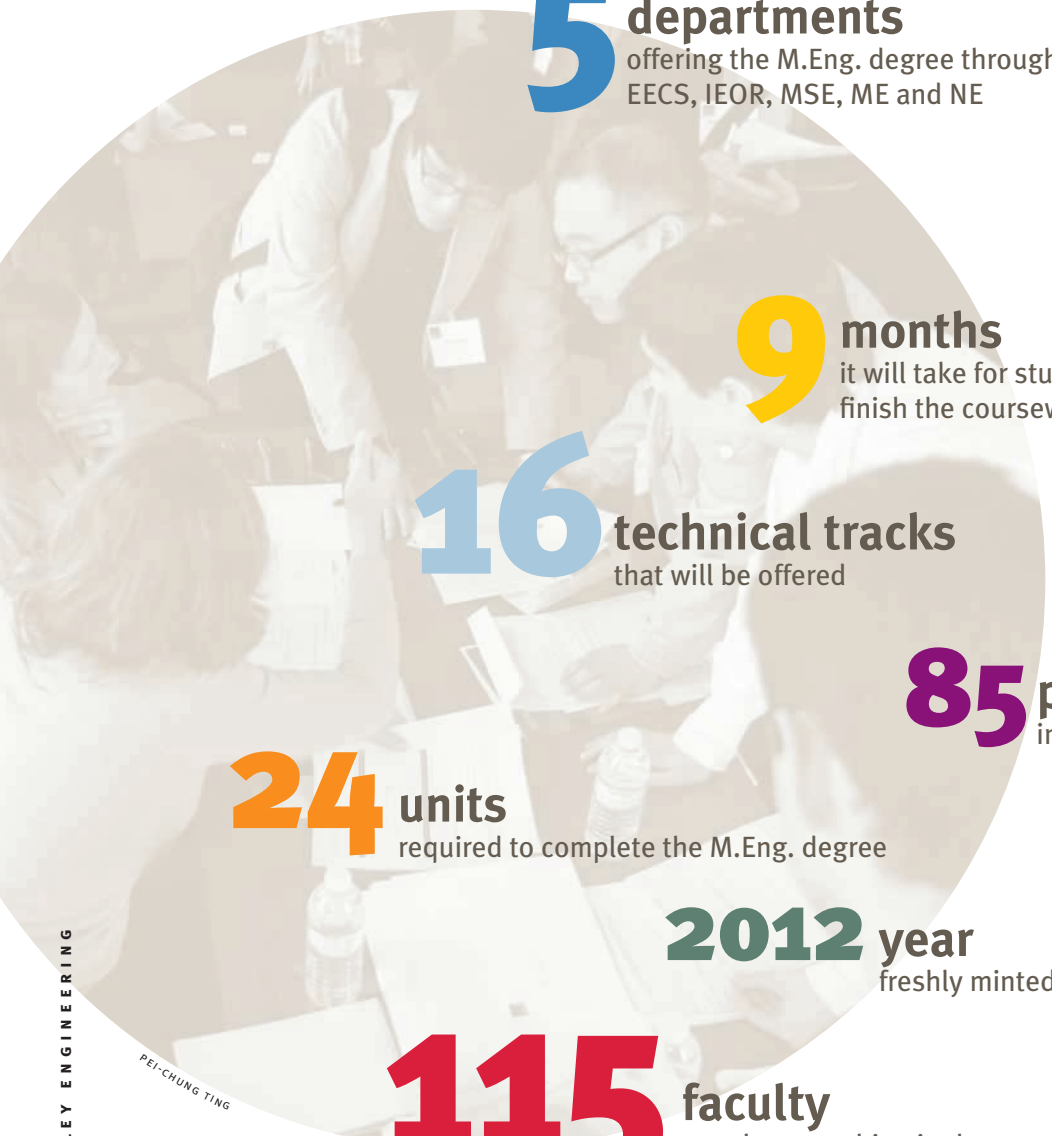
For more information, go to: **http://funginstitute.berkeley.edu/masters**



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offering the M.Eng. degree through the program: EECS, IEOR, MSE, ME and NE

9 months
it will take for students to finish the coursework

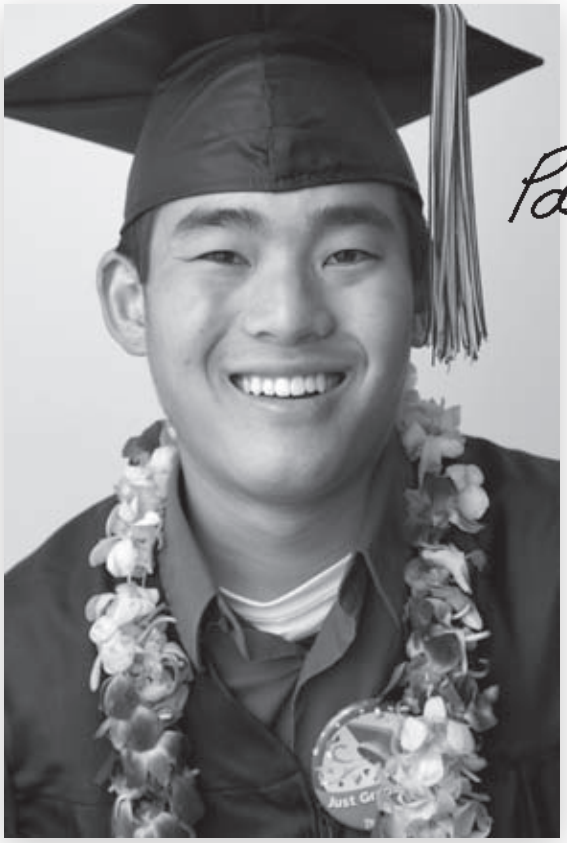
16 technical tracks
that will be offered

85 projected enrollment
in 2011–12

24 units
required to complete the M.Eng. degree

2012 year
freshly minted grads of the program will hit the streets

115 faculty
members teaching in the program



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