Engineering a Renaissance
Graduate Areas

- Applied Mathematics
- Applied Physics
- Bioengineering
- Computer Science
- Electrical Engineering
- Environmental Sciences and Engineering
- Mechanical Engineering

Collaborative Graduate Programs

- Engineering and Physical Biology
  (with the Faculty of Arts and Sciences)
- Science, Technology and Management
  (joint with the Harvard Business School)
- Medical Engineering and Medical Physics
  (with the Harvard/MIT Division of Health Sciences and Technology)
- Systems Biology
  (with the Harvard Medical School)

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A Boston Globe editorial writer was so intrigued by Professor of Applied Mathematics and Mechanics L. Mahadevan’s approach to research, she wrote:

“His philosophy should be inspiration to anyone who wants to keep his or her own gray matter nourished. Seeking an understanding of everything—from a strange plant in a pot to the outermost dust in the cosmos—is the zest of science, and the best way to meet the challenge of living.”

That boundless approach to research and to life characterizes the culture you will find here. We provide the raw materials to foster future leaders who connect ideas in unexpected ways, integrate technical innovations into everyday life, and apply knowledge and discoveries to improve society and further our understanding of the world. We are looking for students who will make their vision real and who will challenge those around them.

This brochure—its message told, in part, through the words of our graduate students—will introduce you to the opportunities available for graduate study in engineering and applied sciences at Harvard University.

If you like what you find, we want to hear from you.
We are at a time of transformation. As breakthroughs in science, engineering, and technology continue to transform our world, Harvard University has firmly committed to strengthening its own science and engineering enterprise to enhance education, advance research, and better society in the 21st century.

The Harvard School of Engineering and Applied Sciences will be a key player in this exciting future. We will have a critical role in fostering direct knowledge, from understanding how materials bend and fracture to understanding atomic-scale phenomena. In addition, we will work to advance basic science through the creation of new tools and approaches that enhance fields from biology to chemistry to physics.

In pursuing our vision, HSEAS will grow, but will remain a different kind of engineering program: rooted in science, interdisciplinary in culture, embracing Harvard’s breadth and depth across the sciences and professions.

We take great pride in what we do—and as important—the way in which we do it. Inspiring the next generation of leaders, discovering new theories and technologies, and solving the world’s most pressing problems, will take courage, creativity, and most essential, collaboration. By approaching every challenge with a nimble mind and open arms we will transform engineering and applied sciences at Harvard and beyond.

I invite you to learn more and become part of a vibrant community.

Yours,

Venkatesh “Venky” Narayanamurti
Dean, Harvard School of Engineering and Applied Sciences

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Current research
Head of research laboratory in nanoscience and technology with 10 researchers, students, and postdoctoral fellows.

Past positions
+ 6 years as Dean, College of Engineering, University of California–Santa Barbara
+ 4 years as Vice President of Research and Exploratory Technology, Sandia National Laboratories
+ 19 years at Bell Laboratories; last post as Director of Solid State Electronics Research Laboratory

Education
+ Ph.D. in Physics from Cornell University
+ B.Sc. (Hon) and M.Sc. in Physics from University of Delhi

Hobbies
His recreational loves are running, squash, and his cottage on Cape Cod, where he relaxes by reading, catching up on research, and listening to music.
On September 20, 2007 Harvard officially christened the Harvard School of Engineering and Applied Sciences, the first new Harvard school since the John F. Kennedy School of Government was created 71 years ago as the Graduate School of Public Administration.
Some graduate students arrive at Harvard with a clear idea of what they would like to study.

Others arrive with a strong desire and steadfast determination to pursue research, but are open in terms of the particulars.

In both cases, and in every case in between, Harvard provides the intellectual breadth and resources to allow you to discover your own path. As nearly 40 percent of engineering and applied sciences faculty hold joint appointments, students have the opportunity to cross fields without ever having to leave the lab.

Moreover, HSEAS has increasingly strong ties and links with Harvard’s professional schools (including medicine and business), other universities throughout the world, and companies in the high-technology sector.

“My advice to the incoming students is to be open-minded when meeting various faculty members,” says bioengineering graduate student Yun-Ling Wong. “There is not one ‘right’ path. It is an exchange between colleagues and mentors to share and learn from one another. Be open to learning from others, especially those outside of your direct field of work.”
World of options ...

Graduate student Rebecca Nesson lives several lives all at once. In addition to studying computational linguistics and tutoring at local Cambridge Rindge and Latin High School, she is the instructor for “Virtual Worlds”, a course that takes place in Second Life, offered at the Harvard Extension School. Nesson is also a 2001 graduate of the Harvard Law School and an affiliate of the Berkman Center for Internet & Society.

Back to school ... David Malan ’99 (Ph.D, Computer Science) says that while in graduate school, he founded two startups: Crimson Tutors and Diskaster and worked part-time for the Middlesex District Attorney’s Office as a forensic investigator. On the side, he volunteered as an EMT-B for MIT-EMS. Currently he’s teaching the intro to computer science course at Harvard College. “As for what’s next, I expect to do something entrepreneurial or pursue opportunities in money management.”

Student-teacher-entrepreneur ...

Kelly Heffner turned out to enjoy being a student, teacher, and an entrepreneur. The Ph.D. candidate was named an outstanding teaching fellow for teaching in some of the most important courses for concentrators in the undergraduate program. She’s taken a “breather” of sorts from her studies, founding a start-up company with two fellow Harvard Ph.D. candidates called Instyll.
Yun-Ling Wong

Areas of Research
Biological Engineering, Global Health

Affiliations
Harvard School of Engineering and Applied Sciences
David Edwards Laboratory: Aerosol Drug Delivery
Harvard School of Public Health
MIT

Education
Massachusetts Institute of Technology, S.B. in Chemical Engineering; S.B. in Biology

Hometown
Lincoln, Rhode Island

“Using engineering to solve biological problems and taking an interdisciplinary approach has broadened my horizons. I am able to get the best of many worlds: strong engineering background ... and the biological, medical and global health perspective from the School of Public Health.

“My research is at the edge of chemical engineering and biology. Our team is working on a novel method for delivering the tuberculosis vaccine. We collaborate with a biological/infectious disease lab. In each meeting, the biologists are teaching the engineers something new and vice versa. The best exchanges are when we stop each other and say, ‘I know this might be a dumb question, but...’

“Ultimately, the direct application and need for this vaccine is a compelling motivator. Knowing that there is a possibility to make a difference motivates me to continue to persevere.”
During junior high Wong met a superstar—and became hooked on research. MIT Professor Robert S. Langer, a founder of modern chemical engineering, offered her advice on a science fair project. Several years later Wong not only spent her high school years working in Langer’s lab but also enrolled at MIT as an undergraduate to study chemical engineering and biology. Today, the Harvard Ph.D. candidate investigates novel drug delivery methods and keeps in close touch with the once mentor whom she now counts as a friend and colleague. Wong also keeps in contact with her alma mater in other ways, serving as an alumni advisor and active participant in her former sorority, Kappa Alpha Theta.
Faculty and students pursuing engineering and applied sciences are linked with the enormous breadth and expertise of the entire University.
At Harvard you can connect ideas and innovations from all fields.

We have close physical and intellectual links with the basic sciences, from physics to statistics; increasing ties with the Chemistry and Biology departments; and significant joint efforts with Harvard’s professional schools, including those of medicine and business.

Our parallel role is bringing advances in applied sciences and technology to society through collaborations with industry and government institutions. Harvard is also home to two major research centers, focused on nanoscience and materials, and a grid computing infrastructure through IBM.

We have institutionalized a collaborative approach toward other disciplines. This is a place where many of the paths for connections have been laid; you simply need the willingness to travel and the drive to discover the unexpected.

The power to connect

The University offers a unique stage for promoting the best in basic and applied research in science and technology, including:

- a commitment to fundamental research supported by a community of distinguished faculty—from biologists to chemists to physicists to engineers
- novel work in engineering, applied sciences, and technology that cuts across fields and departments
- access to one of the best medical centers in the world—Harvard Medical School and its links to 18 affiliated hospitals—and world-class schools of business and law

In everyday terms, this means that faculty members like Maurice Smith, Assistant Professor of Bioengineering, can easily blend engineering with neuroscience and medicine. A member of the newly formed Center for Brain Science, Smith studies the motor coordination of people with Huntington’s disease, an incurable genetic disease in which involuntary erratic movements develop in middle age.
Areas of Research
Complex systems, game theory, electrical and computer engineering

Affiliations
Harvard School of Engineering and Applied Sciences
Renault F1 Racing Team

Education
McGill University (Canada), S.B. in Electrical Engineering

Hometown
Montreal, Canada

“I’m currently studying the price of self-interested behavior in decentralized coordination problems, and how simple interaction protocols can reduce this price.

More generally, I am interested in distributed computing and multi-agent systems with particular emphasis on the derivation of robust, adaptive control mechanisms using economic incentives and models of agent rationality.

I’m also a shameless dilettante of political philosophy—a taste I acquired, strangely enough, during my undergraduate career in electrical engineering at McGill University.”
Corbo took the idea of a fast track Ph.D. program literally. “I spent 2006 working for Renault F1,” he says, referencing the popular European car racing sport. “It was a wonderful ride, filled with exotic fruit, journalists’ questions, an amazing cast of teammates, jet lag, and countless cups espresso. And all of it in the name of research, incidentally at least.”

All of this begs the question of what computer science and game theory has to with F1 racing (or a Ph.D. for that matter). It turns out that F1’s complex racing rules make a day at the track ripe territory for theory. When a racing team decides to make a pit stop—to add fuel and change tires—is tied to the decisions made by competing teams (and vice versa). Thus, the Renault team recruited Corbo to apply game theory to ensure that every second counted (and was accounted for).

The results: The Renault team clinched both the 2006 Drivers’ and Constructors’ World Championships.
Engineering is inherently interdisciplinary and integrative. Not only does it expose students to multiple fields, it also inspires them to collaborate and learn together—skills that are essential in everyday life and work.
We have entered an era of “integrationist” science and engineering.

Life scientists draw on the expertise of chemists, physicists, engineers, and computer scientists to help them observe, analyze, and simulate complex biological processes, such as how cells differentiate and grow.

In the same way, engineers and other physical scientists take inspiration from nature, with the goal of applying some of its elegant solutions—the structure of spider silk or molecular motors—to the development of human-made materials and other engineered products.

To be successful at integrative science, researchers—from computer scientists to engineers to biologists—require the intellectual and physical resources to transcend existing disciplinary boundaries and collaborate with colleagues from other areas. We supply the means. You supply the mind.

In the words of Harvard systems biologist Walter Fontana, “The issue is to inoculate academic Petri dishes with special breeds of computer scientists, biologists, physicists, engineers, linguists, mathematicians, and chemists whose minds can recombine.”
Erez Lieberman

**Degree**
Applied Mathematics and Genomics

**Affiliations**
Harvard School of Engineering and Applied Sciences
Harvard–MIT Division of Health Sciences and Technology (HST)
Harvard Department of Mathematics
MIT Department of Biology
Harvard–MIT Broad Institute

**Education**
Princeton University, A.B. Mathematics
Yeshiva University, M.A. History

**Hometown**
Brooklyn, NY

“You get the sense that people here truly care about interesting phenomena, and will use whatever means necessary to comprehend them. That means you can do physics one day, math the next, then experimental biology, then computer science—whatever it takes—and you don’t have to apologize to anyone for it. It’s not just interdisciplinary; it’s pandisciplinary.

“When I arrived, I knew that I liked the methods of mathematics and physics, but that I wanted to work on biology. So I started out by investigating some beautiful problems at the interface of graph theory and the theory of evolution with Professor Martin Nowak, Professor of Mathematics and Biology and Director of the Program for Evolutionary Dynamics, and with Michael Brenner, Professor of Applied Mathematics.

“But I wanted to start working on problems with immediate medical implications, so I started working on the world’s fastest evolutionary system, the human immune system, with MIT’s Eric Lander at the Harvard-MIT Broad Institute.

“I think there’s no better place than here for seeing the full breadth of the mathematical transformation that is rewiring biology.”
“In finding an advisor, I think you should pick someone who’s work you find really thrilling. It’s worth repeating: really thrilling.” Lieberman says. “Otherwise you won’t have the enthusiasm in the dark of night (which is when I, at least, do most of my work), and the results won’t do justice to your abilities.” He is currently working on large-scale immunoprofiling (a technique for sequencing all of a person’s antibodies in about an hour.) Lieberman reports that his advisors on the project are, in fact, thrilling.
Supporting the push-pull relationship between basic and applied research is our golden rule. Strength in foundational disciplines, from applied physics to computer science, provides a basis for advancing the boundaries of knowledge and creating new technologies.
From understanding the behavior of materials to investigating the chemical origins of life, fundamental exploration remains an essential part of our mission.

In certain areas of research, we are known as a quiet giant. While less flashy on the surface, our reputation for nurturing basic science sets us apart. Our faculty members have published some of the most commonly cited conceptual research papers that have elucidated general principles.

At the same time, we are building a strong foundation for invention-oriented disciplines, such as computer systems research, and increasing our collaborations in broad fields like electrical engineering. The development of technologies like sensor networks and future labs will foster innovative tools and techniques in areas such as small-scale science and bioengineering.

Our faculty and students work at the interface of basic and applied research. Here you can be a thinker and a doer: part Einstein and part Edison.

Applying the tools of the trade

Assistant Professor of Electrical Engineering Ken Crozier recently set up a new lab dedicated to nanophotonics. His particular interests focus on developing greatly improved imaging techniques for scientists and building new devices based on photonic crystals, materials used to control and manipulate the spread of light. Continued advances will likely lead to new fabrication methods.

Professor of Environmental Chemistry Scot Martin is developing the Harvard Smog Chamber. The chamber allows Martin to create particles of a complexity similar to what's actually in the atmosphere. The indoor approach also offers a great advantage: Every ingredient in the smog recipe will be known and accounted for. Because the emission of organic particles is potentially changing how clouds form, which in turn affects climate change, Martin hopes his miniature pollution box will help unravel the recipe.
“To make a graduate degree in engineering effective, you need a strong foundation in the sciences upon which engineering fields are built. I chose Harvard over other graduate programs because it provides that strong foundation.

“I work in a lab at the Medical School developing new imaging techniques for osteoarthritis with researchers who have both engineering and medical backgrounds. It is nice to interact with different kinds of people because it gives you the feeling that there is no problem that will arise in your research that cannot be solved. There is always someone that you know who has the necessary expertise.

“I’ve realized that the goal is not to define scientific fields but to solve the problem with whatever skills might be needed.”
Diop, a native of Ghana, first came to Harvard as part of the Research Experience for Undergraduates program.

During the summer of his junior year he worked in bioengineer Kit Parker and applied physicist Professor Robert Westervelt’s research groups to build a micromagnetic cell stretcher, a chip that generates magnetic fields to apply stress on cardiac cells. In addition to research he says, “I spend a lot of my time teaching kids at the Cambridge Community Center. I believe that society has given so much to me and that it is my duty to give something back. I would like to give the kids that I teach the chance to apply to Harvard someday. It is my hope that I will be able to go back to Ghana or some other third world country and apply my skills.”
Connect
Integrate
Apply
» Build a Better World

The Harvard community is in an ideal position to further a better understanding of the societal importance of science and technology and to foster connections that extend well beyond the ivory tower.
To solve great social problems, science itself must become a social endeavor.

“Veritas” means a willingness not simply to explore frontiers, but to help light the way for the rest of the world. Harvard students and faculty have an exceptional opportunity—and an obligation—to become a resource for anyone confronting the evolving scientific and technological landscape.

That’s why local high school teachers are encouraged to experience life in our labs and take the latest research back to the classroom. That’s why we hosted Introduce a Girl to Engineering Day, designed to encourage young women to pursue careers in science and engineering. That’s why a research associate in Atmospheric Chemistry traveled to South Africa to teach in a program that draws students from across the continent, immersing them for nine months in mathematical concepts and problem-solving.

The core of Harvard’s institutional values is to promote the betterment of society and to further our understanding of the nature of the universe. Doing so entails a continuing dialogue over theory and empirical data, research and applications, means and ends, problems and solutions.

Ultimately, we provide an opportunity for graduate students to be active, engaged, and trailblazing participants in this ongoing conversation.

Making a difference

“Having worked in the spine implant industry prior to coming to Harvard, I saw firsthand the problems associated with nonbiological implants. I am proud that I recognized a clinical need not currently being met in industry and had the courage to devote the next five years of my life to pursuing a solution to it.”

—Kristy Shine, Ph.D. candidate, Medical Engineering and Medical Physics

“I am working on projects that have the potential to make a difference in the world. Many researchers are content with characterizations of known phenomena or small alterations of current techniques. Here at Harvard I believe that the professors ask big questions and the solutions really have the potential to affect people’s lives.”

—Adam Siegel, Ph.D. candidate, Bioengineering

“One of the most fulfilling aspects of working in bioengineering is being able to combine the humanitarian aspects of medicine with the innovation of engineering to address unmet medical needs. Long hours in the lab yield a tangible product that can be used to help people.”

—Jean Chen-Ann Sung, Ph.D. candidate, Bioengineering
Jorge Cham introduces his well-loved comics website by saying, “Piled Higher and Deeper” is the comic strip “about life (or the lack thereof) in academia.”

Of course, academics and research at Harvard translate into hard work and long hours. People are dedicated to what they do. But finding a work-life balance and pursuing outside activities and passions are critical to being successful as a scientist and engineer. So our faculty and students go outside the Yard, participating in the arts—from photography to dance—and taking off stress by racing motorcycles, hiking mountains in New Hampshire, or running the Boston Marathon.

On campus, quick pick-up games of Frisbee, soccer, or even volleyball (there are two sand courts in short walking distance on the north side of campus) are common sights. In Maxwell Dworkin, which houses faculty in computer science and electrical engineering, the new social center/café offers community members a place to chat, grab an espresso (available 24-hours a day), or even watch a Red Sox Game. Graduate students from across Harvard also share Dudley House, a student center that hosts parties and special events, lunch table discussion groups, dinner speakers, dances, faculty/student dinners, movies, ski trips, pub nights, and outings. Students may also participate in intramural athletics, a chamber orchestra and chorus, a jazz/swing band, and public service activities.

While the comic strip may treat graduate student life as a oxymoron, our students say they find there’s plenty of life at Harvard—in the lab and beyond.
The sport of engineering ...

“I lead ski trips; hikes in the White Mountains; rafting and kayaking trips; Red Sox, Celtics, and Bruins outings; apple picking; and whatever other fun things we can think up,” says environmental sciences and engineering graduate student Rynda Hudman of her experience of Dudley House, a center at Harvard University for students in the Graduate School of Arts and Sciences. “I have truly been able to work hard, play hard. Can you tell I love what I do?!”

The ohm of engineering ...

Where do hard working engineers and applied scientists go to relax? The social space/café in Maxwell Dworkin features light fare, espresso, and coffee drinks, and a flat screen television—ideal respite from the pressures of the lab. The new and nearby Laboratory for Integrated Science and Engineering (LISE) offers a ground-floor patio that gives researchers from different disciplines a central place to hang out. Finally, the remodeled Gordon McKay Library is a great place to catch up on the latest journals or to simply gaze out onto the leafy yard below.

The flame of engineering ...

Each year, students and faculty present a holiday lecture designed to inspire the next generation of engineers and scientists. Volunteering is a common way for the SEAS community to give back. One presentation in particular, “The Science of Candlelight,” lived up to the hype (and heat). While many of the younger kids mimicked the twists and turns of the flame, most remained engaged, eager to participate, and open to learning about science during a lecture that lasted nearly the length of a standard Harvard class.
GRADUATE PROGRAMS

Students may work towards a Master of Science, Master of Engineering, and Doctor of Philosophy degree in one of four subjects—Applied Mathematics, Applied Physics, Computer Science, and Engineering Sciences—or graduate with a Ph.D. in the Science, Technology and Management program (with Harvard Business School).

In keeping with the interdisciplinary nature of modern research, we do not have traditional academic departments and do not award degrees by specific research area (listed on the facing page).

The Ph.D. requires a minimum academic residency of two years beyond the bachelor’s degree. Programs are individually tailored and approved by a committee on higher degrees. Normally, students spend one-and-one-half to two years on coursework—12 half-courses, with at least six in a major field and four in adjacent areas. Wide latitude is allowed in the selection of adjacent areas in order to promote diversification of academic interest.
Research Areas

We offer degrees that cover research topics in several broad areas as well as collaborative options. Study/research is not limited to the topics below; most students pursue work that covers multiple areas.

° Applied Mathematics
° Applied Physics
° Bioengineering
° Computer Science
° Electrical Engineering
° Environmental Sciences and Engineering
° Mechanical Engineering

For additional information on our programs and requirements, visit www.seas.harvard.edu/academic/gradstudy/index.html

Collaborative graduate programs

Engineering and Physical Biology
(with the Faculty of Arts and Sciences)
http://www.physicalbiology.fas.harvard.edu
The goal of the Engineering and Physical Biology Ph.D. track is to create a new generation of young scientists who can work comfortably, and simultaneously, in both the life sciences and the physical sciences.

Science, Technology and Management
(joint with the Harvard Business School)
http://www.hbs.edu/doctoral/programs/stm
This Ph.D. program, a collaboration with the Harvard Business School (HBS), seeks to develop new methodologies and to generate research that explores in depth the interaction between information, technology, and management. Areas of emphasis include: Accounting and Control; Competition and Strategy; Marketing; Negotiation, Organizations, and Markets; Organizational Behavior; and Technology and Operations Management.

Medical Engineering and Medical Physics
(with Harvard-MIT Division of Health Sciences and Technology)
http://hst.mit.edu
Harvard’s programs in engineering and applied sciences and the departments of Biophysics and Physics participate in the Harvard-MIT Health Science and Technology (HST) Medical Engineering and Medical Physics Program (MEMP), including a specialized tract in Bioinformatics and Integrative Genomics (BIG).

Systems Biology
(with Harvard Medical School and FAS)
http://sysbio.med.harvard.edu/phd/index.html
There are several faculty in engineering and applied sciences affiliated with the Systems Biology Department. Engineering and applied science students have the opportunity to work with faculty from that department on research projects. Students here, however, receive a degree in Engineering Sciences rather than in Systems Biology.
FACULTY & RESEARCH

Our faculty members are naturally adventuresome (and encouraged to be so); they work beyond traditional boundaries, allowing problems and answers to develop on their own terms, unfettered by fields. Here’s a small selection of what they do.

Research highlights

1. *Hot ice, cool science* … Harvard physicists have shown that specially treated diamond coatings can keep water frozen at body temperature, a finding that may have applications in future medical implants. Graduate student Alexander Wissner-Gross and Efthimios Kaxiras, physics professor and Gordon McKay Professor of Applied Physics, spent a year building and examining computer models that showed that a layer of diamond coated with sodium atoms will keep water frozen up to 108 degrees Fahrenheit. The layer should be thick enough to form a biologically compatible shield over the diamond surface and to make diamond coatings more useful in medical devices.

2. *Easy money* … David Parkes, John L. Loeb Associate Professor of the Natural Sciences, and colleagues modified a peer-to-peer video sharing application, called Tribler, to explore a model for electronic commerce that relies on file uploads and downloads as a form of currency. The team incorporated simple rules into the Tribler software to best harness the power of peer-to-peer while minimizing the problems. The more a user uploads content (i.e. earns) and the higher the quality of the contributions, the more a user would be able to download later (i.e. spend) and the faster the download speed. Thus, the ebb and flow of bandwidth becomes a form of global currency.

3. *Heartfelt engineering* … In an innovative marriage of living cells and a synthetic substrate, bioengineers at Harvard University have found that a rubberlike, elastic film coated with a single layer of cardiac muscle cells can semi-autonomously engage in lifelike gripping, pumping, walking, and swimming. The researchers, led by Kevin Kit Parker and Adam W. Feinberg, report that the exact movement undertaken by these hybrid muscular thin films (MTFs) can be tailored by controlling muscle alignment relative to the shape of the flexible film.

4. *A good ear* … Assistant Professor of Electrical Engineering Patrick Wolfe provided expertise on all things audio for a PRX radio piece about Igor Stravinsky’s recording of compositions in the American Legion Hall. A musician himself, Wolfe uses his expertise in mathematics and statistics to inform his research and draws on psychoacoustics, the relationship between physical stimulus and perceptual sensation, to develop statistical models of how we hear. In particular, he’s looking for better ways to preserve signal quality, since reducing static inevitably occurs at the expense of signal resolution (i.e., quality).

5. *Good sense* … Harvard University, BBN Technologies, and the city of Cambridge have begun a four-year project to install 100 wireless sensors atop streetlights in Cambridge, Mass., creating the world’s first citywide network of wireless sensors. Called CitySense, the wireless sensor network developed by computer scientists at Harvard, including Associate Professor Matt Welsh, and BBN Technologies, a technology solutions firm in Cambridge, will focus initially on monitoring air pollution and weather conditions, collecting data on a scale never before attempted.

6. *Engineering muscle* … Gordon McKay Professor of Bioengineering David Mooney and colleagues developed a new approach for transplanting cells that shows promise for regenerating injured and diseased tissues and whole organs. “We transplant the cells on a scaffold that keeps them alive, then directs
them to leave in a controlled manner and migrate into the surrounding tissue,” explains Mooney. The strategy successfully heals lacerated muscles in mice, but the potential exists for applying it to a wide variety of situations in humans, including treatment of muscular dystrophy, heart disease, and some brain disorders, and to regenerate bone. (photo by Jon Chase, Harvard News Office).

Tiny bubbles ... Howard Stone and colleagues demonstrated that gas bubbles can exist in stable non-spherical shapes without the application of external force. Translation: bubbles can break free of their characteristic round forms and flex their skins into pea pod-, doughnut-, and sausage-shaped versions. The new fangled bubbles are created by coating ordinary gas bubbles with a tightly packed layer of tiny particles and then fusing them.

Structured thinking ... Assistant Professor of Physics and Chemical Engineering Vinothan Manoharan, completed his dissertation by building new optical materials out of particles the size of one-hundredth the diameter of a human hair. In the process, he found that the minute particles organized themselves into atomic-looking structures. Living things, he explains, are chemical structures, and the physics behind self-assembly remains one of the greatest mysteries of biology. “I would like to get to the point where we know the rules we have to follow in order to design the building blocks that are going to assemble by themselves. It’s one of the most important questions around.”

Fantastic fliers ... Rob Wood, Assistant Professor of Electrical Engineering, is working to develop tiny flying vehicles weighing in at one gram or less. His goal is to produce autonomous (no pilot) low-cost fliers that can cover a wide area using gliding or active flight. Using insect-inspired optical-flow motion detection, large numbers of fliers could rapidly fan out to scout an area. Rather than looking for a piece of fruit to perch on, the machines could use sensors to check for potential forest fires or incorporate onboard audio or visual detection systems to enhance search-and-rescue missions in hard-to-reach or dangerous places. He anticipates using novel prototyping methods and lasermicro-machined composite materials to craft stiff and lightweight links, articulated joints, and rigid exoskeletons and airframes for his future fleet.

Disease detectives ... Charles Lieber and his colleagues have developed silicon nanowires that can detect the presence of cancer in the body long before the disease takes hold—even when a cancer marker constitutes only one hundred billionth of the protein present in a drop of blood. The device could enable doctors to prick a patient’s finger and scan the drop instantaneously, detecting with exceptional accuracy the exact type of cancer.

For a complete look at research, related faculty research groups, and research facilities, visit www.seas.harvard.edu/research

For a look at research happening throughout Harvard, see www.researchmatters.harvard.edu
Economic and social impact

Harvard University’s overall economic impact on the Boston area’s economy is more than $3.4 billion (2002 figures, reported by Appleseed, Inc.). Our faculty play an increasingly large role in sustaining this growth engine by developing new technologies, from new types of materials like black silicon to novel drug delivery methods like nanoparticle inhalation, and by supporting critical basic research ranging from quantum physics to theoretical computer science. In addition to fostering relationships with industry and government labs, Harvard serves as an “incubator” for new ideas and has dedicated programs that aid faculty and student innovation and entrepreneurship.

Fostering new ideas

Support networks: Harvard Alumni-Startups was founded in the late 1990s by three Harvard graduates as an informal networking group for Harvard-affiliated folks to share ideas and experiences regarding entrepreneurship. Over the past few years their email list has grown to close to 2,000 people from all over the world. The organization holds a range of activities, seminars, and meetings to help support their members’ efforts.

Courses: The "Mini-MBA" in entrepreneurship offers Harvard students a semester-long menu of topics, ranging from opportunity recognition to how to navigate, and sometimes circumnavigate, the land of venture capital and start-up finance. The modular, cocurricular structure allows students to customize the content and pace of their learning. In keeping with the real-world emphasis of the course, stellar faculty from the Harvard Business School as well as some of Cambridge’s most successful practicing entrepreneurs teach the seminars.

Industrial Partnerships: Annual events include workshops, such as Bioengineering, Materials Science, and Nanosystems, dedicated to promoting collaborations with members of government and industry. Key topics included the creation and use of novel biomaterials; organ repair with engineered tissues; novel drug delivery technologies; and nanotechnology/bionanotechnology.

Creating new companies

Raindance Technologies: The company is devoted to discovering, developing, and commercializing the precise manipulation of minute amounts of fluids in microfluidic devices. 2005; David Weitz (Applied Physics).

Liquid Machines: Computer scientists created this leading provider of Enterprise Rights Management (ERM) solutions to protect critical business content and audit usage while enabling collaboration. 2004; Michael D. Smith (Computer Science).

Pulmatrix: Grown from a novel course, this venture-funded startup develops products that diagnose, treat, prevent, or inhibit the spread of airborne infectious diseases. 2003; David Edwards and students (Bioengineering).
Emerging areas of expertise at Harvard

- Computational Biology and Neuroscience
- Computer Systems Research
- Electrical Engineering and Devices
- Environment and Energy
- Nanoscale Science and Engineering
- New Materials and Structures
- Physics and Engineering of Complex Systems
- Quantum Science and Technology
- Scientific Computing and Information Technology
- Scientific Concepts and New Tools
- Systems Biology, Biophysics, and Bioengineering

Acronyms for research

CRCS  The Center for Research in Computation and Society provides a dedicated and supportive environment for scholars to tackle fundamental computational problems arising from societal issues, such as privacy and security, digital copyrights, and file sharing.

CNS  The Center for Nanoscale Systems focuses on how nanoscale components can be integrated into large and complex interacting systems.

HIBIE  The newly proposed Harvard Initiative in Biologically Inspired Engineering, in collaboration with the Medical School and its teaching hospitals, aims to better understand how biological components work together and to develop new techniques that could lead to improved therapies and medicines.

IIC  The Initiative in Innovative Computing (IIC) fosters the creative use of computational resources to address issues at the forefront of data-intensive science.

IQSE  The Institute for Quantum Science and Engineering supports cross-disciplinary research and education in new areas at the intersection of nanoscience, atomic physics, device engineering, and computer science, that in various ways seek to apply principles of quantum mechanics to advanced technologies.

KIBST  The Kavli Institute for BioNano Science and Technology (KIBST) seeks to develop a deeper understanding of the functioning of life and biology at the nanoscale level.


NSEC  The Nanoscale Science and Engineering Center combines "top down" and "bottom up" approaches to construct novel electronic and magnetic devices with nanoscale sizes and to understand their behavior, including quantum phenomena.
CAMBRIDGE, BOSTON, AND MORE

What’s life like here? Quite simply, that’s up to you. It’s what you make of it and what you bring to it.

Harvard graduate students have ample opportunities to take advantage of what the University, a dynamic community within a hub of higher education, and the surrounding area, a richly complex city of surprisingly small dimensions and a broad range of attractions, have to offer. Cambridge boasts everything from street musicians to fine dining. Local institutions are also all within easy reach, including Fenway Park, home of the Red Sox, and the Museum of Fine Arts, home of some of the best examples of American painting.

Fodor’s, the travel guide experts, entry on Boston captures the complexity and energy you will find: “History and culture can be found at every turn in Boston, but a down-to-earth attitude can always be found on the edges of its New England pride. The city defies stereotype because it consists of different layers.”

While the weather and traffic can be unpredictable, you are brisk walk away from one of the most beautiful urban parks in the U.S., a short subway ride away from the ocean, and a few hours drive away from the White Mountains of New Hampshire, the peaceful beauty of Vermont, and the stunning coastline of Maine. Harvard graduate Oliver Wendell Holmes called Boston the “hub of the solar systems”, but one of its best benefits is all that surrounds it.

Community and support

Harvard is an extremely diverse, cosmopolitan, cultural community. The University and the Graduate School of Arts and Sciences provide extensive support for students from all walks of life and from all parts of the world.

Related efforts, such as the Harvard Foundation for Intercultural and Racial Relations, sponsor events for the entire Harvard University neighborhood, and the W.E.B. Du Bois Graduate Society caters to supporting ethnic groups among the graduate student population. Engineering and Applied Sciences also has its own Graduate Student Advisory Council.

Explore the hub ...

The best way to experience Boston and Cambridge is in person and on foot. Virtual pedestrians can learn more here:

www.boston.com
www.cambridge-usa.org
www.harvardsquare.com
www.gsas.harvard.edu/student/index.html

The city serves as the gateway to all New England, from leaf peeping to hiking to sailing to skiing. For more, see www.newengland.com
FINDING A FUTURE

A Harvard degree opens up doors.

Our graduates have gone on to take positions at some of the finest research institutions in the world, including: Ben Gurion University (Israel), Carnegie Mellon University, Columbia University, Cornell University, MIT, National University of Singapore, Princeton University, University of California–Berkeley, University of Chicago, University of Sydney (Australia), University of Virginia, and right here at Harvard.

“I plan on continuing to do research either in academia or industry,” says Mary Elizabeth Hughes, a Ph.D. candidate in Applied Physics. “I am certain that my research interests will continue to evolve, so I hope to find another environment where interdisciplinary work is encouraged!”

Those pursuing careers in industry and government have worked for technology companies such as Pixar, Google, and IBM; defense contractors such as Northrop Grumman; policy and research organizations such as the National Institutes of Health; banking and investment firms like Citigroup; and environmental consulting groups like Boston-based CDM.

Others have become entrepreneurs. Our graduates started Tacit Knowledge Systems (www.tacit.com) and SupplyWorks, Inc. (www.supplyworks.com). In fact, some of the most well-known companies in the world were started by Harvard graduates—for example, Electronic Arts, 3Com, Sun Microsystems, and Microsoft.

“In addition to teaching and research, I would like to consult for high-tech firms and governments on matters related to innovation and strategy,” says David James Brunner, a Ph.D. candidate in Information, Technology and Management. “At some point in my career, it would be fun to spend some time as an entrepreneur, a venture capitalist, or a senior strategy executive.”
Follow the leader … Zhigang Suo (Ph.D., Engineering Sciences), Gordon McKay Professor of Mechanics and Materials, Harvard University, followed his mentor John Hutchinson (Ph.D. Mechanical Engineering), Abbott and James Lawrence Professor of Engineering, in more ways than one. Both earned their Ph.D.s at Harvard and both ended up becoming tenured faculty members at the School of Engineering and Applied Sciences. Moreover, together, they authored one of the most cited papers in the field of engineering: “Mixed-mode cracking in layered materials.”

Smooth operator … William Peine (Ph.D., Engineering Sciences) is an Assistant Professor of Mechanical Engineering at Purdue. He teams up with medical doctors to create versatile surgical robots for the operating room. “I always loved robots as a kid. I remember signing up for middle school classes and talking about studying robotics,” he recalls. “I was still saying that when I graduated from high school, and I’m still enjoying the thrill of hooking up motors, electronics, and software.”

Farsighted … Gregg Favalora (S.M., Engineering Sciences) serves as the CTO for Actuality Systems, a company that develops spatial 3-D visualization systems. He is a winner of the BFGoodrich / National Inventors Hall of Fame’s Collegiate Inventor’s Competition; a $10k winner of the MIT $50k Entrepreneurship Competition; and a member of Technology Review magazine’s “TR100,” a group of 100 of the top technologists under the age of 35.
We encourage prospective students to visit the campus and meet with members of our Academic Office.

All students admitted to our Ph.D. program receive full financial support. This includes tuition, fees, and a cost-of living stipend ($2,300 per month before taxes in 2007-08).

Support is independent of need provided a student remains in good academic standing and is making satisfactory progress towards his/her Ph.D. degree.

All students who receive financial support participate in the educational program for about ten hours a week for one term—usually as quarter time teaching fellows or in a similar capacity, during their second year of study.

On an extremely limited basis, financial support is available to students in our master’s programs. Applicants to our master’s programs should complete the Statement of Financial Resources for Graduate Study as part of their application.

Note: All accepted Ph.D. students are invited to an informational Open House held each spring.

Application deadlines for fall:
Full-time students
Preferred: December 14
Final: January 2

All prospective full-time graduate students apply through the Harvard Graduate School of Arts and Science (GSAS).

Part-time (S.M.) students apply directly to the Harvard School of Engineering and Applied Sciences Academic Office. Special Students and those wishing to apply for Visiting Scholar status apply directly to GSAS. Special Students can apply for general studies or for affiliation with a specific department.

For complete details on the application process, see www.gsad.harvard.edu
www.seas.harvard.edu/admissions/grad

If you have questions, please contact us at:
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