Start Engineering

ENGINEERING CAREER GUIDE

UPDATED THIRD EDITION

LEARN ABOUT:

- The many fields of engineering
- Where and what to study
- How to improve our world
- New green technologies to combat climate change

AND MUCH MORE!

GREAT Minds in STEM

Engineering is everywhere!

Champions aren't made over night. They are forged over the course of a lifetime.

America needs more champions in engineering and science, and we need them now. From infrastructure to the Internet, computer chips to biochemistry, energy to the environment, national defense to international finance, our economy is fueled by the great minds who power these industries. Competition from around the world has closed the lead the United States enjoyed for much of the last century, and our status as the world's technological leader is in jeopardy.

But the United States has a secret weapon –YOU! You and your peers are a home-grown supply of future engineers and scientists right in our own back yards. We have an infrastructure of motivated teachers and parents who can help prepare you for a successful STEM future. We have community colleges and universities bursting with opportunities to support and guide you toward a STEM degree and beyond. We have corporations, government agencies, research institutions and military commands ready and willing to hire you upon graduation. And we have generations of accomplished STEM professionals ready to be your role models and mentors on your road to success.

We need more of you to pursue degrees and careers in STEM. We need you to embark on a quest to become champions in your chosen fields. Great Minds in STEM is here to help you along the way, and we can't wait to cheer for you when you lift the trophy!

Sincerely,

Dr. Juan Rivera,
Acting CEO & Chairman of the Board of Directors

Bertha Haro, Executive Director
Great Minds in STEM

GREAT Minds in STEM

explore engineering

what's engineering?

Do you want to be creative, take on real challenges, and make a difference in the world? Want to design fast, quiet, and more efficient cars that help save the environment? Or maybe you want to create cool roller coasters and innovative video games! Using science, math, and the latest technologies, engineers solve problems and create inventions. An engineering degree is the basis for an exciting and challenging career. Here's a quick look at some of the things that engineers are up to. Engineering is...

Helping Veterans

War means wounded vets, and for over 1,000 American veterans of Iraq and Afghanistan, wounds include major limb amputations. When DARPA, the Defense Advanced Research Projects Agency, launched the Revolutionizing Prosthetics program in 2006, upper-limb prosthetic technology was far behind lower-limb technology and a major engineering challenge. It's easy to see why when you think of all that our arms, hands, and fingers do, and with precision. After years of testing, one of the most advanced robotic prostheses ever built is now available. According to the Food and Drug Administration, this is the first agency-approved prosthetic arm that translates signals from the muscles to perform complex tasks. The prosthetic arm can carry out multiple, simultaneous movements, and the wrist and fingers can adjust positions so the robotic hand can precisely control its grasp. DARPA's development of prosthetic arms continues through a range of programs, including one that is providing users a natural sense of touch by means of electronic signals transmitted from mechanical hands directly to the brain. This is great news for anyone who needs an upper-limb prosthetic.

Exploring Outer Space

SpaceX's Dragon spaceship is like ridesharing...off-planet! So far, it has delivered only cargo to the astronauts on the International Space Station, including a December 2018 delivery with holiday goodies. According to NASA, the robotic spacecraft also carried a trove of science gear for 250 experiments, including a robotic in-space refueling demonstration and a powerful GEDI laser to study Earth's forests. Also catching a ride: a team of space-traveling mice and 36,000 worms. If all goes to plan, though, SpaceX and Boeing will begin sending American astronauts later in 2019, ending Russia's monopoly on rideshares to the ISS. In anticipation of having space taxis, NASA is now building commercial partners an ISS parking spot! Elon Musk, a Canadian-American engineer and inventor, created SpaceX with the goal of revolutionizing space technology, and eventually building a human colony on Mars. Amazing progress toward that goal!

Feeding the World

Engineers look to improve how we live, from space stations to our dinner tables. While genetically engineering fruits and veggies may have you asking why, altering the DNA of plants we eat can help them stay fresh longer and protect us from foodborne illnesses. Take the tomato, for instance. New genetic engineering techniques could make tomatoes more resistant to infectious fungi and bacteria, which means more ripe, juicy goodness for everyone to enjoy. And, with drought a concern all over the world, engineers are experimenting with ways to minimize the amount of water that important staple crops like corn and wheat require. By selecting for traits that increase the rate of photosynthesis, improve the depth of root growth, and decrease water evaporation through leaves, crops can be grown less resource-intensively. Greater efficiency in growing means more food for a growing world population.

Keeping Us Fit

Lots of exercise apps are accessible through your smartphone. But it's not easy to get the visual feedback you need to know you're training properly on a hand-held device. Enter the Mirror! When it's turned off, it is indeed a full-length mirror. But switch it on and you're face-to-face with a trainer who can lead you through a full class of yoga, cardio, boxing, and strength training. Equipped with cameras and speakers, Mirror enables you to see yourself, your instructor, and your classmates (if you're doing a live class) as you work out. In live classes, the trainer can even offer you feedback! Worried that the typically smudgy phone screen will block your view? The entire system is controlled by a companion app to keep the mirror fingerprint-free. And when you're done working out, Mirror returns to serving as a simple mirror.

COURTESY DARPA, SPACEX, MIRROR. ISTOCKPHOTO.COM

Creating the Look

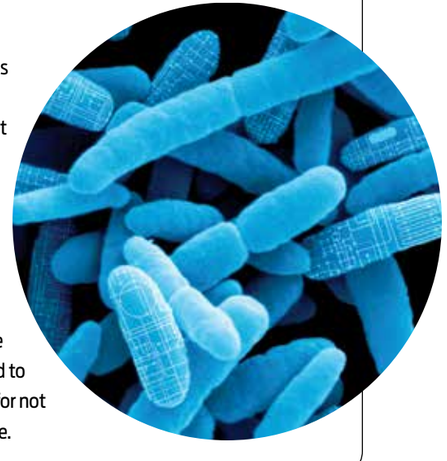
Large research and development labs are most often associated with industries like pharmaceuticals and national defense. However, these days consumer goods companies are leveraging the expertise of scientists and engineers to formulate more effective, cutting-edge products. One of the pioneers in this field remains the South Korean skincare and cosmetics company AmorePacific, which opened its first research labs in 1954. Today, the brand's high-end beauty products are created and tested in collaboration with leading bioengineers like David Weitz, who directs Harvard University's Materials Research Science and Engineering Center. Together they created a delivery system called Microfluidics, which enables the line's ingredients to continuously penetrate to the deepest levels of skin. With close to $4.7 billion generated in sales annually, their beauty secrets are really something to behold.

Crafting Video Games

When you're trying to simulate something as fast-paced and exciting as a basketball game, details matter. The engineers at Visual Concepts say their goal each year is for a smarter, deeper, and more nuanced AI gameplay experience. For NBA 2K19, they've upgraded the play art, stream-lined the "On The Fly Coaching," and enhanced AI play distribution, among other improvements. XboxOne reviewer Ben Vollmer declares that there is "fantastic" quality and attention to detail, from before the tip-off to when the lights shut off in the arena. Thanks to the new emphasis on ball control and maximizing your players' abilities, "Pulling off a Steph Curry step-back jumper or a Lebron James fadeaway is really satisfying, especially because of the work you need to put into learning them first." Sounds like a slam dunk!

Curing Diseases

Trillions of bacteria call your gut home. In recent years, researchers have discovered that this community in our intestines exerts a powerful influence on our immune and endocrine systems, brain health, cognitive function, and even our moods. "It's become really clear that the bacteria living in us and on us affect our bodies in a variety of different ways — in ways that we never imagined," says Dr. Timothy Lu, a biological engineer at MIT. The balance of good and bad bacteria in the intestines can keep us healthy or can contribute to disease. The next step on this exciting medical frontier is to learn how to leverage the power of the gut to treat disease. Lu co-founded Synlogic, a biopharmaceutical lab where engineers are creating medications called "synthetic biotics." They start with probiotic supplements — the kind you buy at any drugstore — and tweak the genetic codes so that the bacteria we house can be made to perform certain functions. For instance, bacteria can be programmed to detect inflammation and then cure it. Ultimately, Synlogic is looking to create treatments for not only rare genetic disorders but also common health threats such as cardiovascular disease.



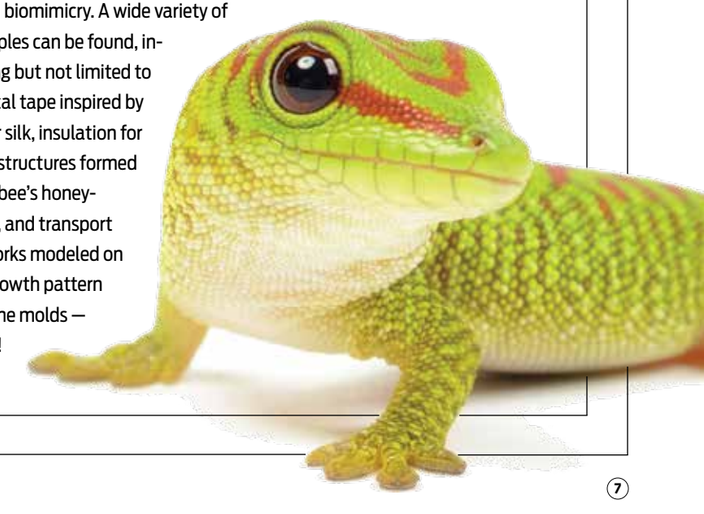
Renault's 100% electric EZ-Ultimo concept car has no space for a driver, can fit a maximum of three passengers, and looks like a luxury lounge.

Designing Driverless Cars

Driverless cars have already hit the road. And with human driving fatalities at an all-time high, that's a good thing. Google started testing driverless cars and trucks in 2009. Since that time, these cars and trucks have driven autonomously, with the vehicle in full control, for eight million miles with only one crash. Google's project, now called Waymo, hopes to fully launch its self-driving ride-hailing service later this year. And BMW, Audi, Toyota, General Motors, Nissan, and Tesla all have models that they hope to get into production by 2020. However, developing autonomous vehicles is proving to be one of the most costly and complex projects for automakers and software makers alike. To control costs, automakers are teaming up with other manufacturers and software providers worldwide to share the technology as it advances. Meanwhile, ethical issues — like how to balance risk to passengers and pedestrians in an unavoidable accident — and cybersecurity concerns present ongoing, challenging "learning opportunities." Engineers, though, are driving hard towards the day when vehicles under the control of artificial intelligence will outperform humans.

Copying Mother Nature

Scaling vertical walls with the ease of Spiderman — whether to escape enemy troops or awkward social situations — may soon be feasible. A U.S. military research team from DARPA reports that engineers have developed a set of handheld paddles that enable soldiers to climb vertical surfaces — an especially useful skill in urban combat. Engineers who designed the paddles were inspired by geckos, a family of lizards known for feats of climbing on what appear to be sticky padded feet. Actually, gecko feet are covered in thousands of tiny fibers called spatulae that help them adhere to surfaces via electrostatic attraction. The practice of taking design cues from the natural world is called biomimicry. A wide variety of examples can be found, including but not limited to medical tape inspired by spider silk, insulation for glass structures formed like a bee's honeycomb, and transport networks modeled on the growth pattern of slime molds — really!



Zipline drones deliver blood to places difficult to access by road.

Saving Lives

Rwanda is among the poorest countries in the world, with winding, unpaved, mountain roads that routinely get washed out in the rainy season. When there's a medical emergency, it's difficult and time-consuming for regional hospitals to get blood, leaving doctors simply unable to perform life-saving operations otherwise possible. Zipline, a drone delivery company in California, decided to tackle this problem. With the cooperation of the Rwandan government, which opened up airspace for the company's drones, Zipline created its first distribution center in 2016, delivering blood when and where it's needed. When an order comes in, bags of blood are packed inside the drone which is placed onto a launcher that catapults the drone into the air. Guided by GPS and other sensors, the drone flies itself to the hospital, drops off the blood, and flies back to base. Zipline has completed more than 8,000 flights to hospitals in Rwanda, literally saving lives. "Billions of people on earth lack access to critical medicine," said Zipline CEO Keller Rinaudo. Zipline plans to expand next to neighboring Tanzania — and the United States.

Learning from Failure

When Boyan Slat was 16, he took a diving trip to Greece and was upset to see more plastic bags than fish. Two years later, he came up with the idea of a floating barrier with a 10-foot skirt to collect the plastic. He called his company The Ocean Cleanup. After over five years of hard work, Slat deployed System 001 out from under the Golden Gate Bridge into the Pacific Ocean. Its destination: the Great Pacific Garbage Patch, a mess of plastic waste twice the size of Texas that is held in position by the currents between California and Hawaii. The system, propelled by wind and wave energy, was intended to corral the plastic, like a huge, buoy-based broom, into a contained area where ships could easily scoop up the trash. Unfortunately, the harsh ocean currents broke System 001. But, Slat learned a lot and vows to make modifications to deploy a new 60-buoy system by the year 2040. "I hope that this will be a turning point for the plastic pollution problem," he says. "For sixty years it has only gotten worse and worse. Now hopefully we're turning the tide."

Harnessing Energy

You've probably noticed thick solar panels on rooftops. Now imagine solar panels clear enough to see through and installed as windows, absorbing the sun's rays for energy! Engineers at Michigan State University have developed a solar cell that captures the invisible wavelengths of sunlight, which are then processed into electricity. "Highly transparent solar cells represent the wave of the future for new solar applications," said Richard Lunt, Professor of Chemical Engineering and Materials Science at MSU. The engineers estimate that up to seven billion square meters of glass surface in the U.S. could be transformed into solar panels, with the potential of supplying 40% of energy demand in the U.S. Now that's a bright idea!

Re-sizing Our Carbon Footprint

A typical pair of running shoes has 65 different parts and demands over 360 processing steps to assemble, from sewing and cutting to injection molding, foaming, and heating. Add in the fact that most shoe manufacturers are in China where coal is the dominant source of electricity, and you get a big carbon footprint for the sports shoe industry. The New Zealand company behind Allbirds shoes wanted to change that. Co-founder Joey Zwillinger, a biotech engineer, developed shoe fabric from sheep's wool — readily available from New Zealand's 30 million sheep! Since wool wicks moisture, the shoes are breathable, comfortable, and sustainable. But Allbirds didn't stop there. Shoelaces are created from recycled plastic bottles, and packaging is made from recycled cardboard. Next up: a flip-flop made from parts of sugarcane that would otherwise be discarded. After all that running, you'll be ready to relax at the beach!

Printing in 3D

For kids who suffer from idiopathic scoliosis or a curvature of the spine, treatment involves wearing a heavy, uncomfortable brace every day for several hours. Many kids are prone to taking it off when parents are not around, making the treatment ineffective. A new custom brace developed by 3D Systems may change this. Since it is created on 3D printers, it can be produced with a near perfect fit. Even better: the brace is flexible and thin, making it comfortable and easy to hide under a shirt. As medical advisor Dr. James Policy of Stanford University remarked, "It was so cool that once they were fitted, many kids were showing off the brace to their friends." The early data from the pilot study indicate that the kids are wearing the devices and reaping the benefits.

SAVING THE WORLD

One Challenge at a Time

Ten years ago, the National Academy of Engineering surveyed the whole world to identify 14 Grand Challenges to ongoing human life that engineers could help solve. A vision for the next 100 years of work, the Grand Challenges point towards engineering feats that would make the world a more sustainable, healthy, secure, and happy place to call home. "We wanted to show how engineering can help guide us in to the future," explains Randy Atkins, director of the Grand Challenges project.

Engineering schools across the country have incorporated the Grand Challenges into their students' learning through the Grand Challenges Scholars Program. Students build competencies in five areas vital to addressing projects with global scope: technical content, multidisciplinary and multicultural perspectives, business savvy, and social consciousness. For students with a yen to change the world, a school with a Grand Challenges Scholars Program could be the first step.

Read on to find out more about the Grand Challenges themselves.

► **Secure cyberspace.** Almost every day, news breaks about hackers invading digital space assumed to be secure. Communications networks, vital infrastructure, international financial markets, national security operations;

Manage the nitrogen cycle

Develop methods for carbon sequestration

Restore and improve urban infrastructure

Advance health informatics

CLOCKWISE FROM TOP LEFT: JONAS ZURCHER/UNSPLASH, ISTOCKPHOTO.COM (2), NICK-FEWINGS/UNSPLASH

Make solar energy affordable

Engineer better medicines using genetic science

Provide access to clean water

Secure cyberspace

all rely on computer-controlled systems that have proven tempting targets for hackers. On all fronts, we need strategies to get ahead of criminal hackers. Encryption and biometric technologies — think fingerprint readers or eye scanners — can help but we'll need other solutions to protect all the world's vulnerable technologies. For more information, see page 18.

► **Develop carbon sequestration methods.** Safely capturing and storing carbon would go a long way to reversing climate change. And it seems to be possible. Experts say none of the challenges to cost-effective carbon sequestration "are serious enough" to keep it from happening. Engineers are working now to make carbon capture and storage possible at a large scale. Burning fossil fuels overloads the atmosphere with carbon dioxide but well-understood chemical reactions can scrub the exhaust of climate-damaging agents. Solutions to storing carbon will probably involve a combination of underground and under-the-ocean-floor locations. Implementation is a costly challenge, but steady progress gives reason to hope.

► **Provide access to clean water.** It's a basic concept, and one we tend to take for granted. But drinking unclean water results in the death of nearly 5,000 children worldwide every day. Engineers are working on cost-effective filtering, distillation, and recycling systems to clean water in developing countries to put a stop to this tragedy. Having adequate supplies of water is also an issue. Since oceans contain 97 percent of the Earth's water, engineers are trying to make ocean water desalination (salt extraction) more efficient and cost-effective.

► **Reverse-engineering the brain.** Figuring out how the brain works and learns could lead to engineered solutions for human neurological problems. Called neuroprosthetics, engineers and scientists in this field have already made progress: paralyzed monkeys given a brain implant were able to walk again. Understanding how the brain works also drives progress in artificial intelligence, another frontier on which engineers are already at work.

► **Restore and improve urban infrastructure.** If America's water, sewer, transportation, and energy systems were students in school, they would be bombing out as D+ performers, says the American Society of Civil Engineers. Old, overused, and undersized, infrastructure systems are in dire need of revival. As more people congregate in urban areas, the challenge only grows to refurbish and build systems allowing lives, business, and society in general to function. Engineers are working on new construction methods and materials as well as making better use of current resources. But funding has been scarce, and the disruptions required by repairs and renovations will be great. The quicker we can come up with creative, durable solutions, the better and cheaper the fixes will be.

What catches your interest? To read more about these and other Grand Challenges, go to engineeringchallenges.org. For more on the Grand Challenges Scholars Program, go to **engineeringchallenges.org/GrandChallengeScholarsProgram.aspx.**

CLOCKWISE FROM TOP LEFT: ZBYNEK BURIVAL, LOUIS REED, MARKUS SPISKE, RAWPIXEL/UNSPLASH

HOLDING BACK THE OCEAN

A CHANGING CLIMATE DEMANDS ENGINEERING SOLUTIONS.

The vast majority of scientists and engineers are already confronting rising temperatures and rising sea levels as facts, dangerous facts. A small rise in sea levels has big implications.

A University of Miami study recently established that the rate of sea-level rise in South Florida has tripled over the past decade. While seasonal high tides are normal, rising sea-level has triggered abnormally high tides, causing water literally to bubble up through porous ground. Miami Beach, a city of just under 20 square miles and about 100,000 people, has become a national leader in making improvements to protect residents from rising sea levels. The goal is to buy time, hopefully at least 50 years, for Miami Beach to survive as political will grows and engineering solutions develop to tackle the problem of climate change more broadly.

In Miami Beach, engineers developed a network of 80 pumping stations together with a plan to raise roads and increase the height of some existing sea walls. Combining the pumping stations with raised roads is an exciting engineering innovation. The raised streets are less vulnerable to flooding, and the pumping stations direct water away from low-lying areas. Because buildings remain in place, entrances and patios end up several feet below street level but they stay dry! However, preserving city viability and improving safety in a flooding emergency comes at a cost of about $400 million dollars.

If you're interested in working on infrastructure solutions to climate change, most colleges recommend you start with an undergraduate degree in civil engineering, and then get a master's degree in climate change issues. However, the University of Michigan recently created a new undergraduate degree program, the first of its kind, called Climate Science and Impacts Engineering, offered within the Climate and Space Sciences and Engineering department. It's a chance to get an early start on issues that confront our changing world.

PHOTO ILLUSTRATION BY JOSEPH DARROW

Healthy, Sustainable, & Affordable

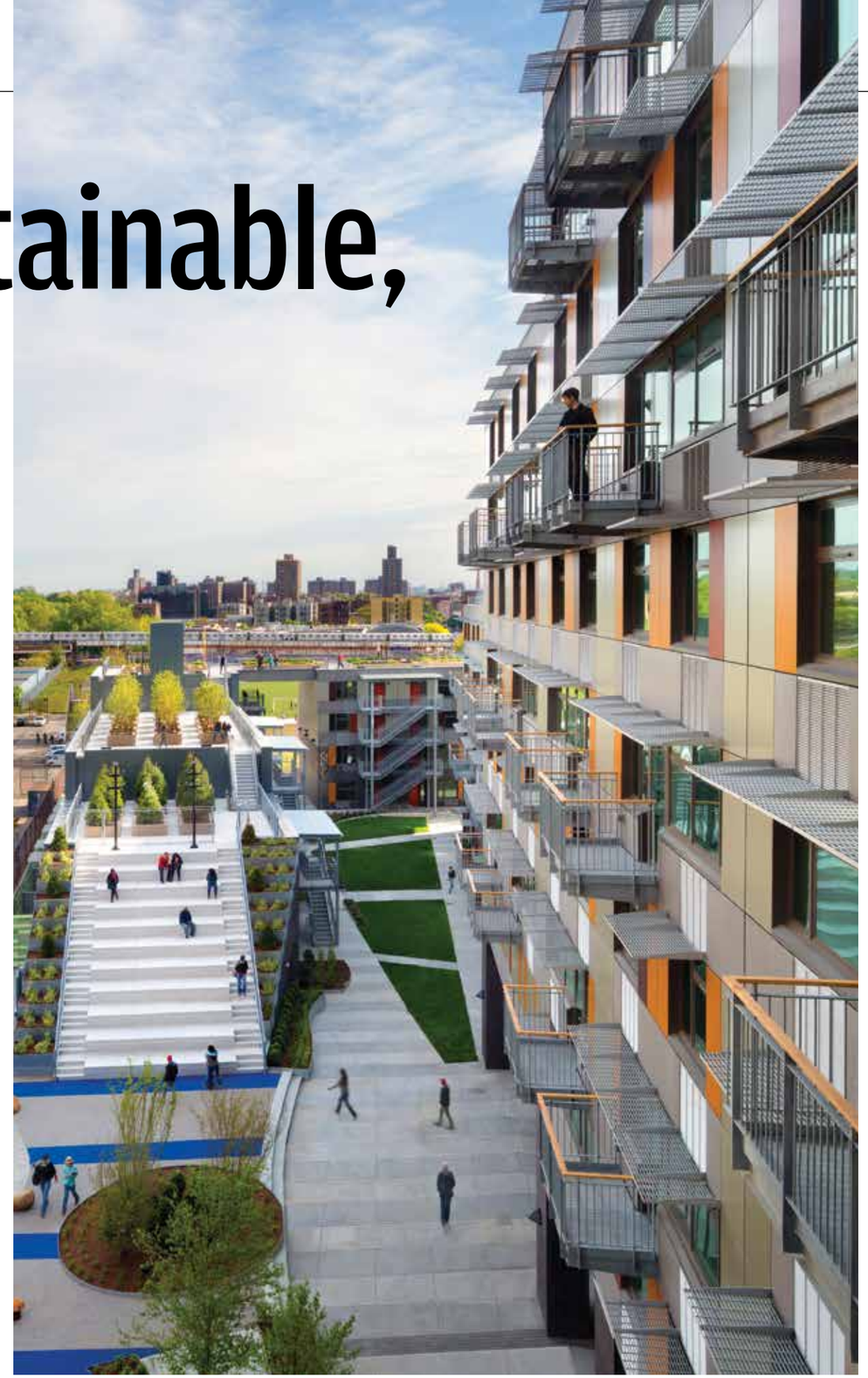
With green roofs and a multitude of solar panels, New York City's Via Verde represents a new model for healthy urban living.

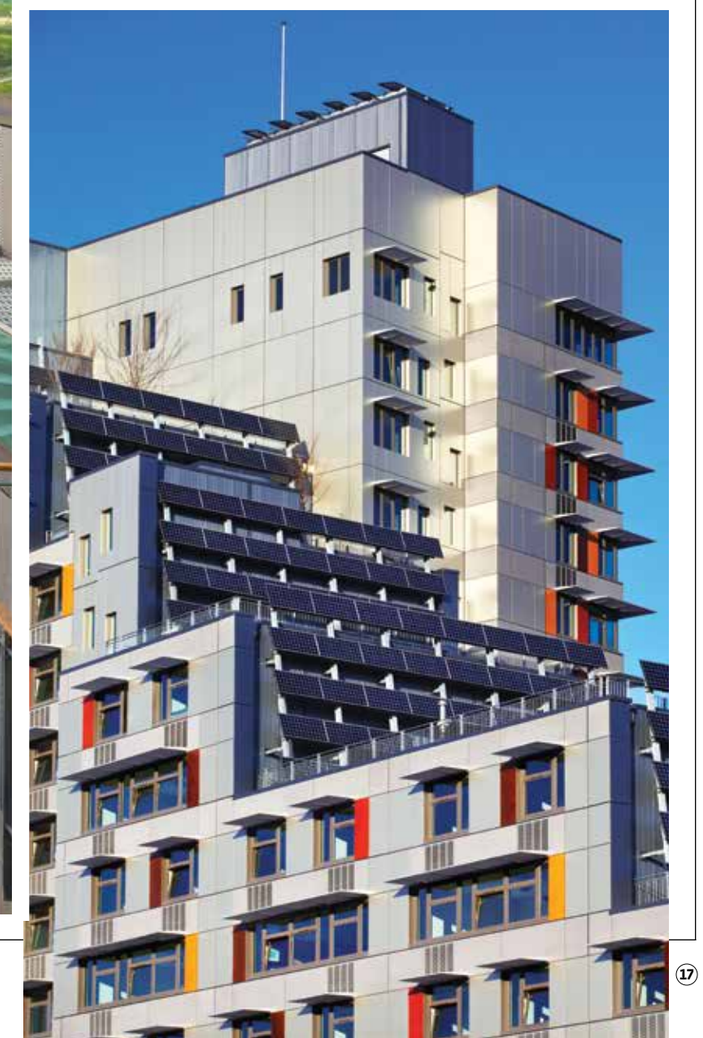
One of the most critical and exciting engineering frontiers is urban planning. Critical, because we know the percentage of city-dwellers is increasing and that providing shelter, energy, and food for our planet's total population has negative impacts on our environment. Exciting, because there are so many possibilities for creativity.

Affordable housing is a buzzword because cities face availability and cost pressures on rents and home ownership. Providing affordable housing is linked to sustainability — having populations living close by jobs and schools reduces stress on the environment. Because we know that relying on fossil fuels for transportation, neglecting water infrastructure, and ignoring neighborhoods without basic amenities don't make for sustainability, engineers are working on strategies that do!

A great example is Via Verde, The Green Way, in New York City. Via Verde is a mixed-use project providing new, affordable housing designed to support healthy living and walkability — another buzzword. Walkability means that important amenities like grocery stores as well as resources for healthcare, culture, and recreation are accessible by foot, reducing fuel consumption and cost of access. Walkability is proven to attract jobs and boost quality of life.

Via Verde has housing units for rent as well as co-ops for ownership for low-through middle-income families, with options in low-rise townhomes, a mid-rise duplex building, and a 20-story apartment tower. There is ground-floor retail and office space, and apartments specifically designed for working from home. But putting in actual green space was just as important to planners. In addition to many open-air courtyards, connected rooftops and walkways give shape to an extensive park. Residents can go for a scenic stroll several stories above the streets, harvest rainwater, and grow fruits and vegetables — all in the middle of the South Bronx!





DAVID SUNDBERG / ESTO

Cyber Warriors Urgently Needed

The advantages of today's increased connectivity bring increased risk to national security, creating a huge demand for computer scientists and engineers.

For more information about careers in cybersecurity, see our Cybersecurity Career Guide at http://start-engineering.com/-cybersecurity-career-guide/

The numbers tell the story: there are currently over **one million job openings** around the world in cybersecurity and that number is projected to rise to 3.5 million by 2021. We now live in a world ever more interconnected through technology. Today's GPS devices, from smartphones to cars, track our every move and collect a staggering amount of data. In 2018, 23 billion electronic devices were connected to the Internet; experts predict that by 2025, there could be 75 billion. Computer scientists and engineers have unprecedented opportunities to share, analyze, and interpret data to increase efficiencies in production, distribution, and maintenance in every field from healthcare and consumer products to scientific exploration and national defense.

However, this vast collection of data creates security risks for individuals, businesses, and governments. How to protect, hold, and exchange information worries people from entities as diverse as defense and intelligence agencies, healthcare providers, and commercial and financial organizations.

Criminals and other governments may launch cyber attacks by hacking into infrastructure like the electrical grid, water supply systems, or air traffic controls. They might hold data for ransom, use it to torpedo rivals, or falsify it to disrupt operations. They may spy by setting up digital pathways — often called tunnels — to gain ongoing access to secret and proprietary information systems. Adversaries may be nation states, such as North Korea, non-nation state actors like ISIS, and criminals looking to make a buck, such as the mafia.

In 2018, the cost of cyber crimes totaled 600 billion dollars; by 2021 the toll is expected to reach six trillion dollars. Skilled computer scientists and engineers are needed not only to create secure data networks but also to generate a cyber offense against nefarious organizations. Luckily, just as common criminals do, cyber criminals leave a trail: digital evidence. Computer scientists and engineers in digital forensics are online detectives, tracing crimes to the perpetrators and gathering evidence needed to convict them in court. They work to create effective strategies for playing both cyber defense and offense.

Many colleges and universities offer cyber security as a specialization within computer science and engineering programs. Top-rated schools include the University of Texas, San Antonio, Mississippi State University, Carnegie Mellon University, Purdue University, and the University of Southern California. Community colleges are also starting to offer specialized training in cyber security.

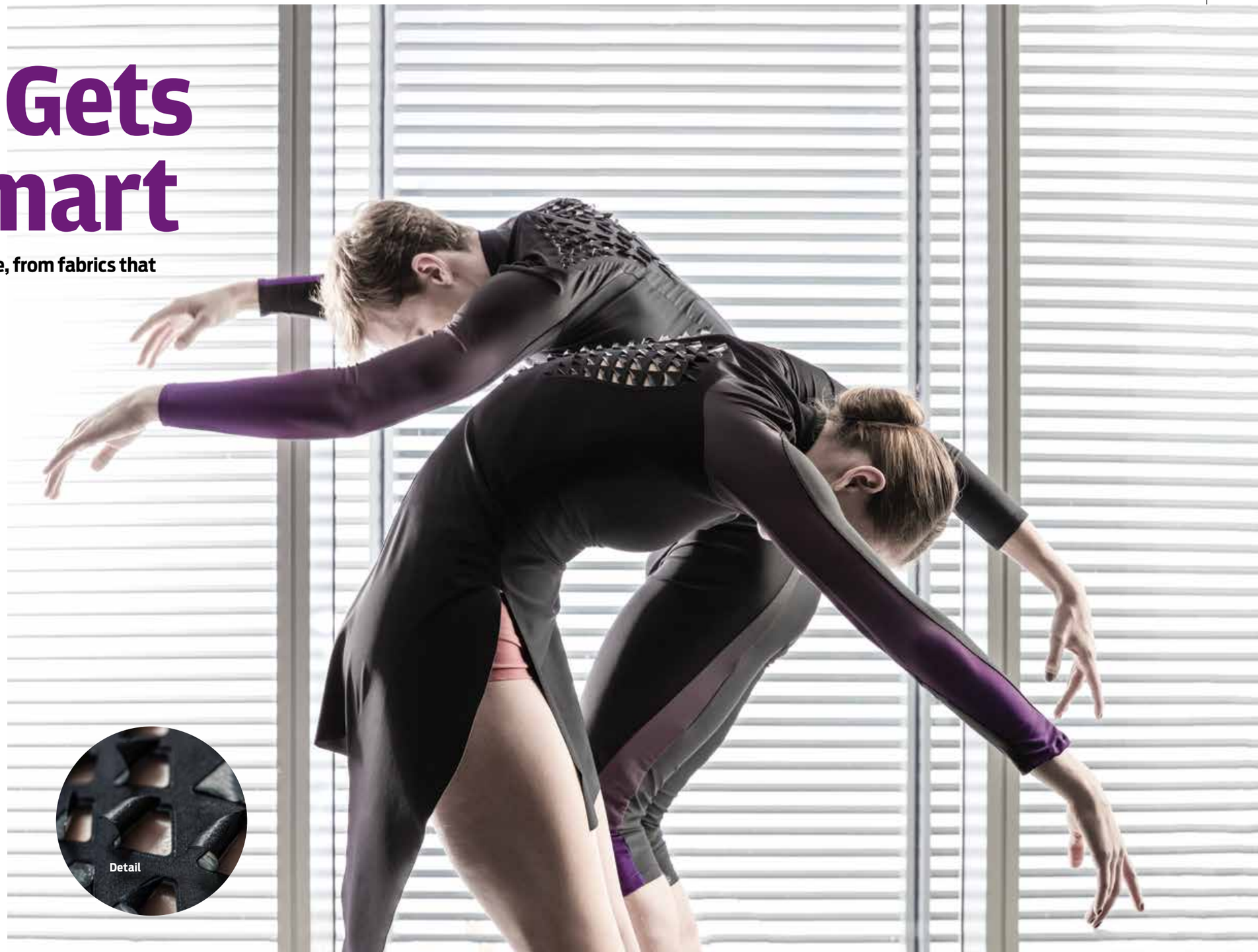
Clothing Gets *Really* Smart

Materials engineers find new ways to amaze, from fabrics that charge, to clothes that breathe.

First there was clothing that lit up with flexible, sewn-in LED circuits. Then, so-called smart clothing arrived for monitoring functions like heart rate and calories burned. Even smarter: Nike's self-tying athletic shoes! Advances in materials engineering just keep coming. Here are a couple more cool innovations:

► **Chargeable clothes.** Phone batteries are notoriously short-lived, causing all kinds of aggravation. Now imagine charging your phone with your shirt or your jacket as you walk around or hang out with your friends outside. Scientists and engineers have been working for years to create fabrics that could harness the energy the wearer generates by walking and moving. Recently, a team at the Georgia Institute of Technology invented a fabric that can gather energy from both sunlight and motion and then store it in embedded fibers. This fabric already has potential in the wearable tech market — think mobile phones, medical devices, infrastructure monitoring, and the ever-helpful GPS!!

► **Living textiles.** In a new twist on the expanding role of technology in fashion, a research team at MIT called bioLogic has embedded fabric with bacteria. The synthetic bio-skin reacts to body heat and sweat, causing flaps around heat zones to open, enabling sweat to evaporate and cool down the body. Together with New Balance, bioLogic is applying this technology to creating sportswear that enhances performance through regulating body temperature. According to bioLogic, "Bio is the new interface. We are imagining a world where actuators [the component responsible for moving or controlling a mechanism] and sensors can be grown rather than manufactured, being derived from nature as opposed to engineered in factories." Sounds great, so long as we don't end up with ants in our pants.



Detail

COURTESY BIOLOGIC

Lending a Hand (or Two)

Stanford University's mermaid robot dives where humans cannot.

How do you think of mermaids? Homer's sirens? Disney's Princess Ariel? J.K. Rowling's toothy lake dwellers in the Harry Potter novels? Engineers have another option: Dr. Oussama Khatib's OceanOne, the robot with "a friendly face" designed for working underwater.

Dr. Khatib is a Stanford University computer scientist specializing in humanoid robots. Like other submersibles, OceanOne must be operated from the surface and can be used at depths greater than those human divers can get to, with no oxygen tanks required. Unlike any other submersible, OceanOne's humanoid features enable it to manipulate objects and show them to the operator.

OceanOne is about 5'2", has two arms, articulated wrists, and hands equipped with haptic feedback — the capacity of transmitting information through touch — so the operator can feel whether the object is firm or fragile, heavy or light. The head has a face with two large eyes, cameras that provide a stereoscopic view. The brain reads data so that OceanOne can maintain direction, dodge obstacles, and adjust its grip as needed. There's no fishlike tail, but eight multi-directional thrusters allow the operator to swim OceanOne into places unsafe for human divers. The possibilities for dealing with underwater disasters and carrying out ocean research are amazing! "You can feel exactly what the robot is doing," Khatib says. "It's almost like you are there."

OceanOne's first dive both made and saved history. Accompanied by watching divers and with Dr. Khatib at the controls in a boat, the merbot retrieved a vase from a sunken flagship of French King Louis XIV. No human had explored its ruins — or the countless treasures and artifacts the ship once carried — since it sank in 1664. OceanOne handled the delicate vase from start to finish, placing it in the recovery basket that carried it to the surface. Based on this astonishing success, it's hoped that the robot will one day take on more highly-skilled underwater tasks too dangerous for human divers, as well as open up a whole new realm of ocean exploration.

COURTESY STANFORD UNIVERSITY

GOING GLOBAL

Engineers Without Borders sends teams of students all over the world to help communities solve problems.

For a career that combines interesting work with helping others — plus financial security — engineering has it wrapped up. Even better: you can start making a difference while you're still in college. Student chapters of Engineers Without Borders send teams all over the world to help communities solve real problems.


Nepal

Nepal is famous for Mt. Everest but is also one of the world's least developed countries. Steep mountains plus isolated plateaus and valleys make building infrastructure like water sanitation systems difficult. Imagine walking miles along dirt paths to and from school and having to wonder whether the water you're thirsty for will make you sick. University of Colorado, Boulder, sends Engineers Without Borders teams to Nepal every year on projects that provide communities in the Ilam District access to clean water. The students on the team are responsible for everything from the grant proposals that fund trips, to visiting prospective sites to talk with locals about what to build, to surveying where and how to build.

But this is not a top-down donation of expertise from developed to developing world. What the team ends up building starts with finding out what the community thinks about what should be built. Students gather information by working with a local non-governmental organization and talking with residents. Recent CU graduate Max Churchill comments that "the awesome, awesome thing is the high level of local ownership of the project."

"Ultimately, it's about what the community wants," says Erica Wiener, the Nepal Secretary for the Colorado chapter. CU also sends teams to Rwanda, Peru. "The focus is on sustainability, rather than on design. That's part of engineering anywhere, to learn how to work with expectations and make adjustments for sustainability." Max Churchill credits his experience in Nepal, which included trekking, with enhancing employability: "Originally, I just knew I wanted to travel. But the fact that as an undergrad I had so much experience working as part of a multicultural team blows people away!"


La Libertad, Peru


Kenya


Nuevo Loreto, Peru


Bolivia


Western Kenya


Thailand


Panama

COURTESY ENGINEERS WITHOUT BORDERS

London Reaches Ever Upward

And relies on structural engineers to make it happen.

London is famous for amazing skyscrapers, from The Shard to The Gherkin. Next up on the horizon: The Tulip, which, at 1,001 feet, promises to be the tallest yet. Designed at the global architectural studio Foster + Partners, The Tulip's design makes for a minimal building footprint and, according to Foster + Partners, will use fewer resources, with high-performance glass, heating and cooling systems provided by zero combustion technology, and integrated photovoltaic cells generating energy on site. But The Tulip is also designed to attract visitors, with 360-degree viewing galleries, bars and restaurants, internal "sky bridges," and external gondola pods that rotate like Ferris wheels. Plus, the architects promise that The Tulip will be a "classroom in the sky" with a high-tech educational center that London schools could use free of charge for educational, cultural, and tech events.

But how do you engineer this revolutionary design? Foster + Partners employs many structural and environmental engineers who work alongside the architects to develop fully integrated construction plans. Steel was chosen for the tower's top framing for the lightness and versatility needed to form The Tulip's unique geometry. Floors at the top of the tower will be made of composite slabs supported by the steel frame. Concrete buttresses at the tower's base are for stiffening the base and reducing bending. Assuming planning permission for the tower is granted, construction is planned to begin in 2020 with the project due for completion in 2025. Foster + Partners intends The Tulip to complement The Gherkin next door, which it also designed, even if flowers aren't usually paired with pickles!

COURTESY FOSTER + PARTNERS

Special Effects Innovators

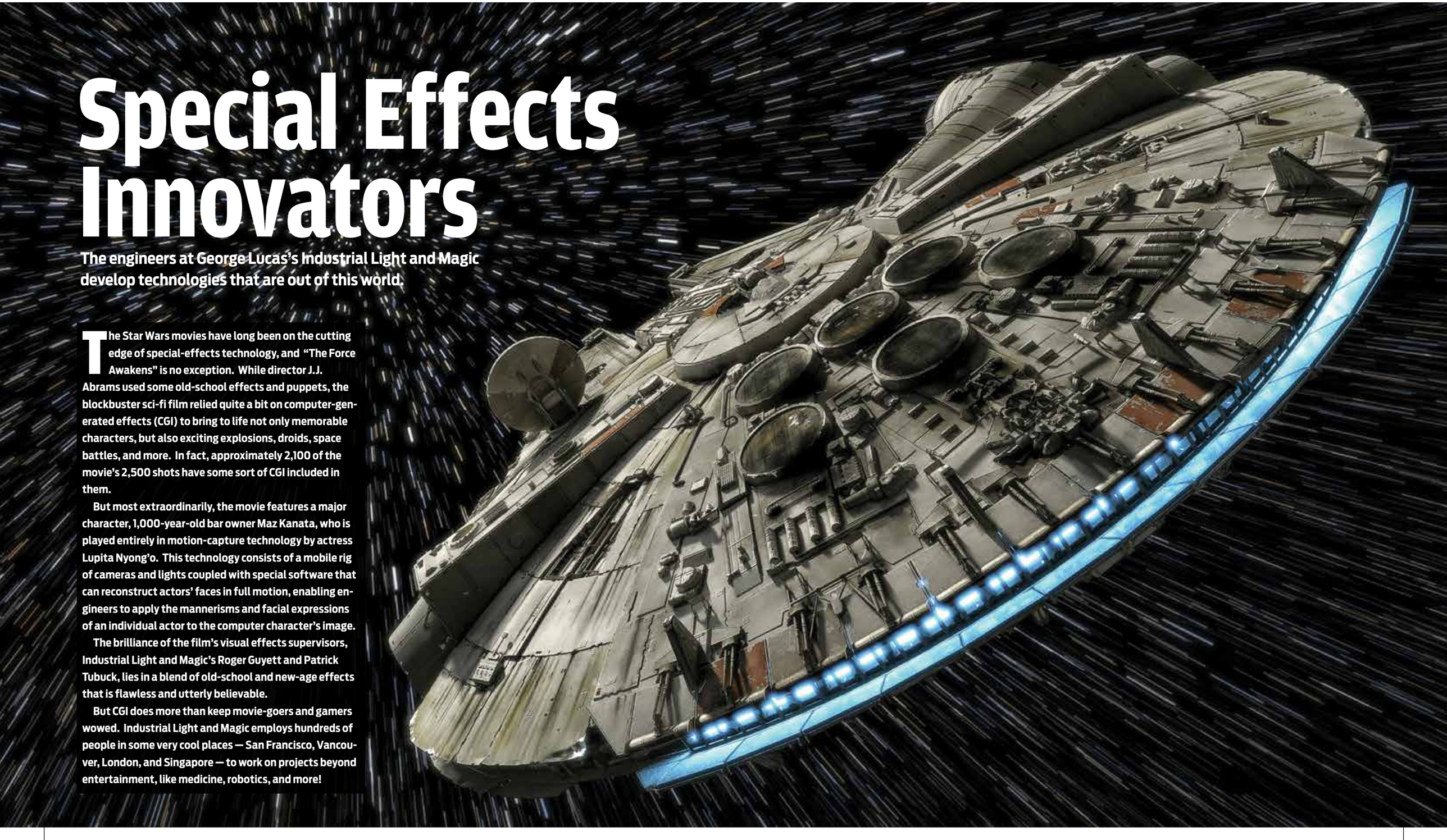
The engineers at George Lucas's Industrial Light and Magic develop technologies that are out of this world.

The Star Wars movies have long been on the cutting edge of special-effects technology, and "The Force Awakens" is no exception. While director J.J. Abrams used some old-school effects and puppets, the blockbuster sci-fi film relied quite a bit on computer-generated effects (CGI) to bring to life not only memorable characters, but also exciting explosions, droids, space battles, and more. In fact, approximately 2,100 of the movie's 2,500 shots have some sort of CGI included in them.

But most extraordinarily, the movie features a major character, 1,000-year-old bar owner Maz Kanata, who is played entirely in motion-capture technology by actress Lupita Nyong'o. This technology consists of a mobile rig of cameras and lights coupled with special software that can reconstruct actors' faces in full motion, enabling engineers to apply the mannerisms and facial expressions of an individual actor to the computer character's image.

The brilliance of the film's visual effects supervisors, Industrial Light and Magic's Roger Guyett and Patrick Tubuck, lies in a blend of old-school and new-age effects that is flawless and utterly believable.

But CGI does more than keep movie-goers and gamers wowed. Industrial Light and Magic employs hundreds of people in some very cool places — San Francisco, Vancouver, London, and Singapore — to work on projects beyond entertainment, like medicine, robotics, and more!



COURTESY ILM

She Walks On Water

Today's enthralling entertainment productions require the skills of engineers to make them happen.

Beyoncé may not be the name that comes to mind when you think of engineering. But her phenomenal concerts depend on talented engineers as much as on talented musicians, dancers, and the Queen B herself!

In 2016, Beyoncé launched the Formation World Tour, an all-stadium series of concerts. Staging included a rotating LED cube nicknamed the Monolith — because at 60 feet tall, it's the equivalent of a seven-story building. One of the major dance acts was performed in a huge pool of water. And now that you're thinking of engineering, keep in mind that these dazzling features needed to work in open-air environments and be set up and taken down at every event!

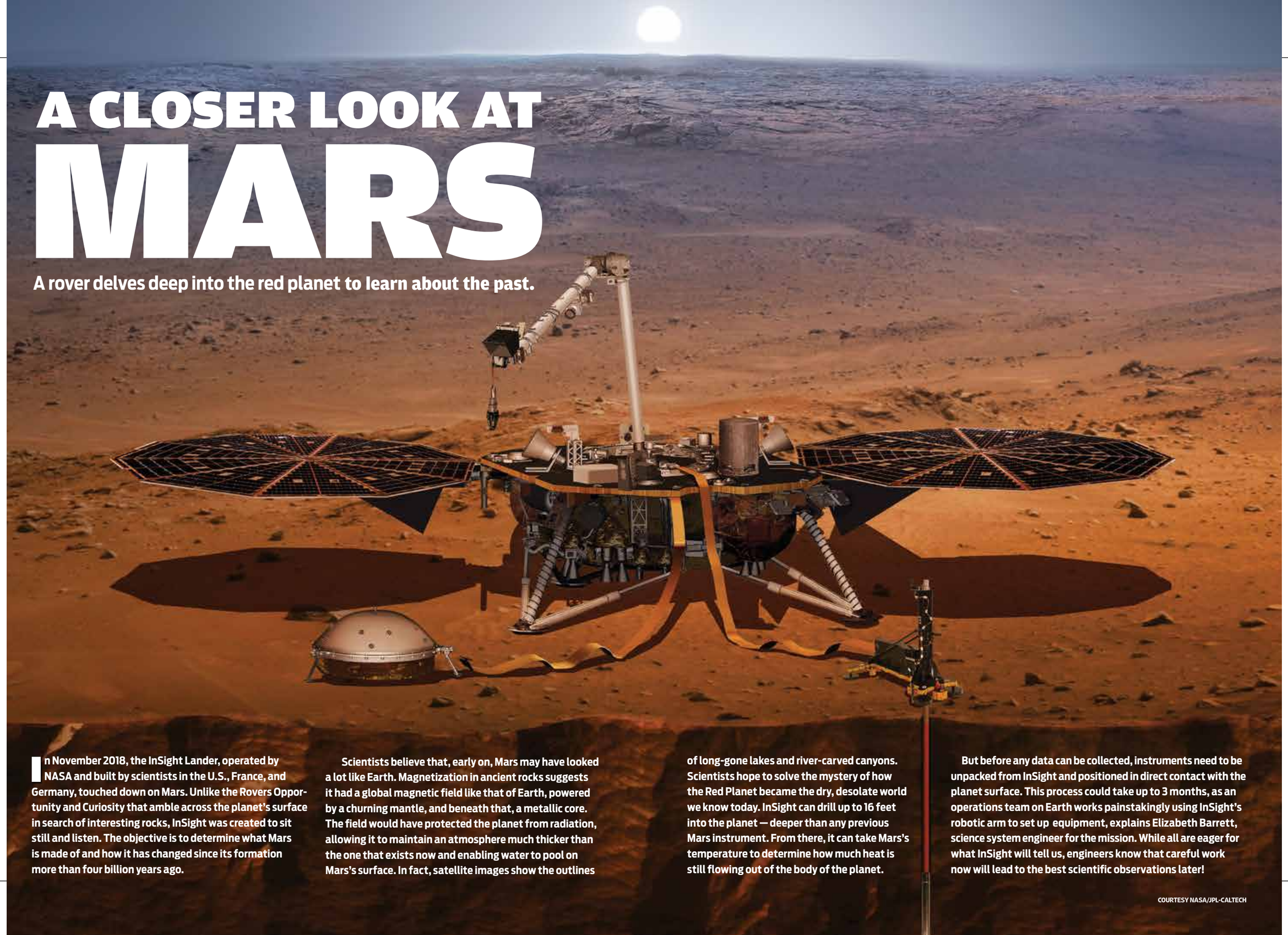
Engineering entertainment demands aligning an artist's intentions with stage design and engineering. Beyoncé worked with McLaren Engineering Group's production designer Es Devlin and engineers from Stageco and Tait Towers to give fans and performers, in the words of senior project manager Brian Levine, an "epic experience." The Monolith represented creative concepts Beyoncé and Devlin dreamed up, but the engineers had to apply the hard science of materials and physics to the art of design for those dreams to come true.

Brian Levine describes the staging as "a game changer for what can be achieved in a stadium touring environment." The rotation time of the Monolith, four minutes, was calculated with both the size of the cube and the activity of performers in mind. Because weather is unpredictable, the treadmill on the catwalk had to be waterproof and safe for use in the open-air venues. And to accomplish the magical appearance of the pool of water, the B stage had to be capable of storing 2,000 gallons of water and imperceptibly filling the space in minutes. Whoa!

FRANK MICELOTTA/AP IMAGES

A CLOSER LOOK AT MARS

A rover delves deep into the red planet to learn about the past.



In November 2018, the InSight Lander, operated by NASA and built by scientists in the U.S., France, and Germany, touched down on Mars. Unlike the Rovers Opportunity and Curiosity that amble across the planet's surface in search of interesting rocks, InSight was created to sit still and listen. The objective is to determine what Mars is made of and how it has changed since its formation more than four billion years ago.

Scientists believe that, early on, Mars may have looked a lot like Earth. Magnetization in ancient rocks suggests it had a global magnetic field like that of Earth, powered by a churning mantle, and beneath that, a metallic core. The field would have protected the planet from radiation, allowing it to maintain an atmosphere much thicker than the one that exists now and enabling water to pool on Mars's surface. In fact, satellite images show the outlines of long-gone lakes and river-carved canyons. Scientists hope to solve the mystery of how the Red Planet became the dry, desolate world we know today. InSight can drill up to 16 feet into the planet — deeper than any previous Mars instrument. From there, it can take Mars's temperature to determine how much heat is still flowing out of the body of the planet.

But before any data can be collected, instruments need to be unpacked from InSight and positioned in direct contact with the planet surface. This process could take up to 3 months, as an operations team on Earth works painstakingly using InSight's robotic arm to set up equipment, explains Elizabeth Barrett, science system engineer for the mission. While all are eager for what InSight will tell us, engineers know that careful work now will lead to the best scientific observations later!

COURTESY NASA/JPL-CALTECH

Hands-On Engineering

Engineering technology offers an opportunity to be on site to make sure the job is completed on time — and on budget.

So, you think you might want to be an engineer. But maybe you'd rather be an engineering technologist. What's the difference, anyway?

Engineers and ET's often work together but have different roles in the design and production of ... pretty much anything! Cars, cybersecurity systems, buildings, transportation networks, and robots start with a design for the functions to be performed and end with an actual product that performs those functions. Having a good design is essential, and that comes from the engineer. But so is having what's needed to make the design a reality, and that's where the ET comes in.

For example, engineers designing a fuel-efficient car will look at many factors — how weight and size affect velocity and how much fuel will be needed to power the car. They think about what the car looks like as well as the aerodynamics that affect fuel consumption. They use principles of physics to determine the engine's fuel burn rate. Plus there are safety requirements and an electronics system in the mix, as well as special features consumers want. In the end, there is a design.

But, in order for this theoretically ideal car to make it from the engineers' computer screens to the showroom floor, there need to be materials out there capable of being used for the design. Assistant Dean Terri Talbert-Hatch of Indiana University Purdue University Indianapolis (IUPUI) observes, "It's possible to come up with all kinds of cool stuff on a computer, but if there isn't material that works for that design, where are you?"

"ET's are literally hands on, researching and finding materials, running experiments, troubleshooting, and doing all that is needed to build the prototype. They are at the computer, too, but they see the final product," says IUPUI Asst. Dean Talbert-Hatch. Generally, the work of the engineer is based in the office, whereas the work of the ET is based in the field. But, notes Talbert-Hatch, in smaller companies, engineers and ET's tend to do a lot of the same things. In bigger companies, roles are more distinct and specialized.

So, in thinking about an engineering-related career, look into Bachelor of Science programs in both engineering and engineering technology. Many community colleges offer two-year associate's degrees in engineering technology, along with industry certifications. But don't feel you need to know which you prefer now. And if you get to senior year still not sure which career path is for you, keep in mind that you can change your degree program from engineering to engineering technology more easily than vice versa.

 ISTOCKPHOTO.COM (5)

PLANNING AHEAD PAYS OFF

Let's say you've decided to apply to engineering schools. Here's your checklist: A strong academic record and good SAT scores. Heartfelt letters of recommendation from teachers. A well-written essay. But how can you set yourself apart from other students?

We spoke with one of the gatekeepers to find out. Marian M. Nicoletti, senior associate director of Transfer Admissions at the Rochester Institute of Technology, told us that top engineering schools look at extracurricular activities to determine which students have the right stuff. "We want students to be more than one-dimensional, to show that they're interested in things other than academics."

Clearly it's wise to check out what's available with an engineering element, such as pre-engineering courses. The nonprofit group Project Lead the Way designs and makes available to K-12 schools across the country project-based STEM courses. If you have an opportunity to take one, do so, Nicoletti urges. Taking part in robotics competitions via organizations such as FIRST or Vex is another natural, so look for an extracurricular or after-school club that offers one of these.

Don't overlook Boy Scouts and Girl Scouts. The scouts who achieve the highest ranks — Eagle Scout or Gold Award — will have worked on a substantial community service project, which Nicoletti says, is "looked at very favorably."

But any kind of community service is a plus. Examples include: volunteering as a Big Brother or Big Sister, tutoring other students, and volunteering in nursing homes. Nicoletti also notes that any kind of part-time job is considered good experience. And a big thumbs-up for activities in music, dance, fine arts, sports — whatever you like that you put effort into doing.

Finally, consider taking a free online coding course from code.org or a drawing class that teaches you how to get your ideas onto paper or tablet. These kinds of extras help demonstrate your interests to colleges.

One caveat: "Don't go overboard," Nicoletti says, and cram too many extracurricular activities into your life. That's a recipe for stress that won't necessarily impress colleges. When schools say they want well-rounded students, that also means students who know when to chill out and just have fun.

CUT YOUR TUITION BILL

If you're looking for financial aid, start with scholarships at the **schools you are interested in attending**. These scholarships are usually the most generous. But there are also numerous engineering scholarships from many sources, such as non-profits, foundations, institutions, governmental organizations, and corporations. Ask your high school counselor to help you find out more.

FIRST Robotics: $1,000 to $20,000 per year for participants in the FIRST Robotics Competition, 167 scholarships. **firstinspires.org/scholarships**

Great Minds in STEM, HENAAC Scholars Program: more than $200,000 in scholarship funds available for Hispanic students. **greatmindsinstem.org**

National Action Council for Minorities in Engineering, Inc. (NACME): $1,500, for African-American, American Indian, and Latino high school seniors. **nacme.org/scholarships-overview**

National Society of Black Engineers: $500 to $10,500. Must be active, paid member. **nsbe.org**

Northrop Grumman: $2,000 per year for four years. **https://www.northropgrumman.com/corporateresponsibility/community/pages/engineeringscholars.aspx**

Regeneron Science Talent Search competition: $25,000 to $250,000 in college money for winners. **student.societyforscience.org/regeneron-sts**

Reserve Officers' Training Corps (ROTC): a merit-based scholarship, covering all or part of college tuition. Basic military and officer training at or nearby the college in return for an obligation of active military service after graduation.

The Robotics Education & Competition (REC) Foundation: $1,000 to $20,000 per year for high school students participating in VEX robotics, 102 scholarships available. **roboticseducation.org**

Science, Mathematics & Research for Transformation Defense Scholarship for Service Program (SMART): $25,000 to $40,000. Provides a stipend, full tuition, book allowance, room and board and more. Must be a U.S. citizen and at least 18 years old. There is an employment obligation to the Department of Defense with this scholarship program. **smartscholarshipprod.servicenow.com/smart**

Society of Women Engineers: $1,000 to $10,000 for a range of scholarships. **societyofwomenengineers.swe.org/scholarships**

Women's Transportation Seminar (WTS): $5,000 to $10,000 to women who are pursuing careers in transportation. Apply through your local WTS chapter. **wtsinternational.org/education/scholarships**

ISTOCKPHOTO.COM

options, options options

Here are some of the most popular disciplines in engineering. This is not a complete list but a look at the major fields. Multidisciplinary engineering is growing and it's likely that you will be engaged in coursework that includes several disciplines. Just because you choose a primary field of engineering does not mean you are "locked into" that one field forever!

Aerospace Engineers

They design and build airplanes, jet fighters, rockets, space ships, and satellites. Aerospace engineers work at places like NASA, where they may design rovers to explore distant planets or plan a human colony on the moon. They are also making light-weight airplanes that burn less fuel, keeping the air we breathe cleaner.

Agricultural Engineers

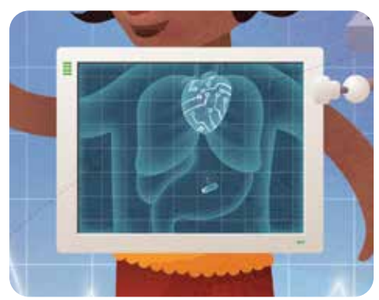
They develop new ways to grow, harvest, and distribute high-quality, nutritious food. Agricultural engineers design vertical farms to be built in cities so crops and livestock can be raised where people live, reducing transport costs. They also are figuring out how to grow food using less water and fertilizer, saving resources and keeping the earth healthy.

Wow! Average starting salary for engineers:

$65,539

Average starting salary for computer engineers is the highest in engineering:

$76,070



Biomedical Engineers

They design, build, and test technologies that doctors can use to diagnose and treat patients. Biomedical engineers design prosthetics (artificial arms and legs) so athletes who have lost a limb can still run, jump, and swim. They're creating artificial organs like hearts, kidneys, and livers, and growing tissues like skin and bone.

Chemical Engineers

They take raw materials and transform them into the things we use every day. Chemical engineers help develop new formulas for life-saving drugs, strong plastics for smartphones, long-lasting paint for buildings, and so much more. They also work to make chemical processes use less energy and generate less waste.

QUICK TIP >
Join your school's robotics team to learn how to program and to practice working in teams. But don't worry if you don't like robotics—there are plenty of other aspects to engineering!

Engineering majors in the class of 2017 have starting salaries that are 30% above the average.

Civil Engineers

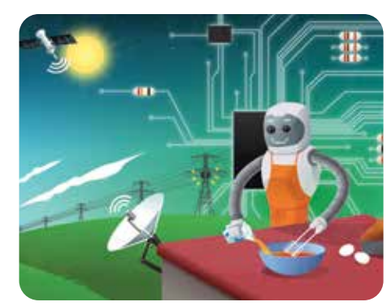
They design and build the structures that we live in and travel on — buildings, roads, canals, and bridges. Civil engineers work on big projects, like hydroelectric dams that produce electricity for an entire region and city subway systems that get large populations from here to there. They also figure out how to use less energy to heat and cool a single structure.

Computer Engineers

They design the software and hardware for computers, smartphones, and all the other electronic gadgets we rely on. They help to design your favorite video game system or social media website, and work on cyber security to protect information. Computer engineers often need to combine electrical engineering and computer science.

Electrical Engineers

They build machines and systems that transmit electricity from where it's produced to where it's used. Electrical engineers also apply their know-how to computer systems and electronics, designing microchips to control robots, game consoles, or tablets. They also help develop wind turbines, solar cells, and other renewable energy technologies.



QUICK TIP >
Be sure to take four years of math and science in high school, but don't sideline your English classes! You need to be able to communicate effectively in college and in the workplace.

SOURCES: AMERICAN SOCIETY FOR ENGINEERING EDUCATION, NATIONAL ASSOCIATION OF COLLEGES AND EMPLOYERS, THE DEPARTMENT OF LABOR AND THE U.S. BUREAU OF LABOR AND STATISTICS

ILLUSTRATIONS BY HUAN TRAN

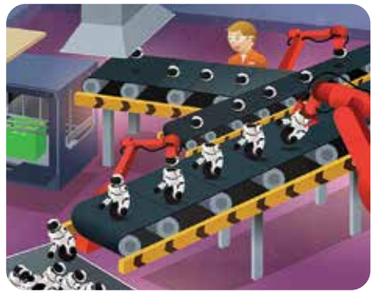
QUICK TIP > Get in touch with a local branch of an engineering society to meet with real engineers. Ask questions to get a feel for what they do.

Environmental Engineers

They devise solutions to the problems facing us with our air, plants, soil, and water. Environmental engineers design systems to prevent and control pollution and conserve the earth's resources. They are also working on new ways to collect and sort waste so that more of it can be recycled. They are also trying to slow down and cope with the effects of climate change.

Manufacturing Engineers

They design factories and systems to make all the stuff that people use today — cars, toys, airplanes, and more. Manufacturing engineers help figure out efficiencies, how to get lots of product quickly without sacrificing quality. They also find ways for factories to use less energy and fewer materials, making production processes cheaper and cleaner.



Materials Engineers

They create new substances out of the basic building blocks of matter, sometimes imitating those found in nature. Materials engineers use chemistry and physics to design materials with just the right properties for whatever engineers want to make. Some work with nanotechnology, like carbon nanotubes, to make new types of electronics and medicines.

The school that issued the most engineering degrees in 2017 was the Georgia Institute of Technology with:

3,060

24%

of all engineering degrees awarded in 2017 were in mechanical engineering.

Mechanical Engineers

They design and build all types of machines and products, often using computers to work out their great ideas in 3-D. Mechanical engineers are found in many fields, designing what's useful — appliances, medical equipment, and cars — and also what's fun — toys, rollercoasters, and the musical toothbrush.

Mining Engineers

They develop techniques for getting minerals out of the ground so we have the needed raw materials to make things. Mining engineers may design mines to dig out precious metals like gold or to extract resources like coal and uranium. They also develop ways to dig underground safely without destroying the land above or polluting the water below.

The average annual salary of a nuclear engineer is over

$109,000

Over 124,000 engineering bachelor's degrees were awarded in 2017, the largest yearly increase in 10 years.

Nuclear Engineers

They design, develop, monitor, and operate nuclear plants used to generate energy. Nuclear engineers may work on the fuel cycle, the production, handling, and use of nuclear fuel, as well as its safe disposition. They may also develop and maintain the nuclear imaging technology used to diagnose and treat medical problems.

Ocean Engineers

They design and build marine vessels, whether ships that sail on the water's surface or submarines that navigate the depths. Ocean engineers also design marine structures, like floating oil rigs and offshore wind farms. They work on solving problems of beach erosion and water pollution, such as the trash from our throw-aways.

Systems Engineers

They think about the big picture, figuring out how to manage complex projects involving people, processes, goods, and information. Systems engineers often need deep knowledge about many different areas, as well as analytical and organizational skills. They work in a wide variety of fields, such as transportation, the military, manufacturing, and software.

QUICK TIP > Apply for summer internships or apprenticeships with firms in your field of interest. A little experience early on can really influence your ultimate career choice.

teamwork

In the real world, engineers often work in teams. Students do the same at engineering programs across the country. Teamwork teaches valuable communication skills and prepares students to face future challenges. Whether it's traveling to Nepal to help build a community center after an earthquake, or developing super-fast racing cars, team projects offer students lots of exciting opportunities. Here are a few examples:

Manufacturing Partnerships

Research deals between companies and universities are at an all-time high. Companies seek access to the best scientific and engineering minds, and universities are happy to have funding to provide students important real-world research experience. Recently, Argonne Laboratories and the University of Wisconsin, Madison, partnered to fuel development of sustainable manufacturing. UW-Madison will help develop and test advanced materials and conduct nuclear engineering and power grid research, making it possible for students to be part of developing new processes for energy efficient manufacturing. A definite win-win situation!

Racing in Concrete

Every year, teams of engineering students from across the U.S. and Canada do the seemingly impossible: make concrete float. Sponsored by the American Society of Civil Engineers, the National Concrete Canoe Competition gives civil engineering students an opportunity to gain hands-on, practical experience by working with concrete mix designs to build a working boat. Expanding student understanding of the versatility of materials is important but so is building teamwork and project management skills. In 2018, California Polytechnic State University, San Luis Obispo (pictured), beat out 24 other teams for first place. The University of Florida took second place.

COURTESY UW, MADISON; CYNTHIA SINCLAIR

Rebuilding After Disaster

A giant earthquake hit Nepal in 2015, killing more than 8,000 people and destroying thousands of homes and businesses. Two University of New Mexico civil engineering graduate students, Lauren Jaramillo and Jennifer Van Osdel, wanted to help. They started UNM4Nepal with a mission to develop humanitarian engineering projects for both rebuilding and training, so that Nepalese could complete needed rebuilding projects themselves. "Our design looks at affordability, constructability, and suitableness of materials," said Jaramillo. Their first project was a community center which the team designed and helped build. The building blocks are "earthbags," polypropylene (plastic) bags filled with soil. The blocks are tamped down to compact them and then, in construction, barbed wire is placed between bags to bind layers together. In a few weeks, the earthbag walls are just as hard and solid as any built with brick and mortar. According to UNM4Nepal, this type of construction is better for earthquake-prone regions, and the fact that local residents do the construction with local materials makes it a great solution for this kind of disaster.

COURTESY UNM, TEXAS A&M, USNA

Driving in the Super-Fast Lane

Every year, engineering students across the U.S. compete in Formula SAE racecar design competitions at speedways in Lincoln, Neb., or Brooklyn, Mich. Each student team designs, builds, and tests a prototype, following competition rules to ensure on-track safety (the cars are driven by the students) and promote clever problem-solving. Students are allowed to receive advice and feedback from professional engineers and school faculty, but must do all car design themselves. In 2018, Texas A&M University's 22-member team took first place in the final competition, beating out 66 other teams. Project manager Spencer Weaver said the team's victory is all the more impressive, given that the car's design was created and fabricated by the students — from scratch — in only nine months. Participating at all competition levels builds skills in engineering, project management, systems integration, manufacturing, and is always quite the team effort!

Outreach at USNA

The United States Naval Academy is committed to getting more kids inspired to pursue careers in science, technology, engineering, and math (STEM). A recent "Girls Only STEM Day" drew 210 middle-school girls who designed and built a catapult launch-and-capture system to simulate delivering humanitarian aid under adverse conditions such as natural disasters and wartime. Other USNA-hosted events include robotics competitions, family STEM nights, and much more. Opening young minds to STEM can be awesomely rewarding — and a lot of fun, as over 70 midshipmen discovered at "Girls Only STEM Day." Go to the Naval Academy and you could be part of it!

REACHING THE GOAL

OK, let's be real. The engineering profession is dominated by white males. Always has been. But that's not its future. The profession is embracing diversity — not only because that's the right thing to do, but because it's essential to quality engineering. As David C. Munson, former dean of the University of Michigan's College of Engineering, explains: "Diverse teams produce better answers, and there's research to back that up." The American Society for Engineering Education (ASEE) agrees: "We learn from those whose experiences, beliefs, and perspectives are different from our own." Moreover, as Munson says, to keep America competitive, "we cannot continue to draw students from only a quarter of the population. That makes no sense at all." Accordingly, America's engineering schools are making big efforts to recruit and enroll more students from underrepresented groups. To help that effort, ASEE created a Diversity Committee in 2011 with the goal of having an engineering community "that looks like America." It promotes model policies and practices to not only help schools attract more women and minorities, but also to ensure that those students are welcomed on campus. Engineering schools now typically host a wide variety of groups — such as the Society of Women Engineers, the National Society of Black Engineers, and the Society of Hispanic Professional Engineers — that offer women and minority students support and guidance. So if you think engineering is where you belong, you're right — no matter who you are or where you're from.

Engineering schools are working hard to attract and retain women and minorities.

ENGINEERING, BY THE NUMBERS

The number of engineering degrees awarded continues to grow, increasing by 10 percent from 2016 to 2017. While engineering continues to be a white male-dominated field, the number of degrees earned by women and Hispanics has shown small increases. However, the number of degrees awarded to African-Americans declined to under 4 percent. Many universities are committed to reaching out to minority groups and women, and some host summer camps and other opportunities for high school students.

SCHOOLS THAT GRADUATE THE MOST WOMEN

1. Georgia Institute of Technology
2. University of California, San Diego
3. University of Michigan
4. University of Illinois, Urbana-Champaign
5. Purdue University
6. Texas A&M University
7. Massachusetts Institute of Technology
8. Virginia Tech
9. The Ohio State University
10. University of California, Berkeley

SCHOOLS THAT GRADUATE THE MOST AFRICAN-AMERICANS

1. Georgia Institute of Technology
2. North Carolina A&T State University
3. University of Central Florida
4. Morgan State University
5. Howard University
6. University of Maryland, Baltimore County
7. Tuskegee University
8. Polytechnic University of Puerto Rico
9. Florida International University
10. University of Maryland, College Park

SCHOOLS THAT GRADUATE THE MOST HISPANICS

1. Florida International University
2. University of Puerto Rico, Mayaguez
3. Texas A&M University
4. University of Central Florida
5. The University of Texas at El Paso
6. California State University, Long Beach
7. The Univ. of Texas Rio Grande Valley
8. University of Florida
9. Arizona State University
10. California State Poly. U., Pomona

SOURCE: AMERICAN SOCIETY FOR ENGINEERING EDUCATION

ON-CAMPUS SUPPORT

Engineering schools have many groups that support women and minorities in their pursuit of an engineering degree. Here are some examples:

National Society of Black Engineers (NSBE) helps students excel academically, succeed professionally, and positively impact the community through NSBE-sponsored career fairs and other events.

Great Minds in STEM (GMIS) offers scholarships and through its college captains program reaches out into local communities to attract minorities to engineering.

Society of Women Engineers (SWE) awards scholarships, offers competitions and job and internship search resources, and runs an annual awards ceremony.

National Organization for Gay and Lesbian Scientists and Technical Professionals (NOGLSTP) provides education, advocacy, professional development, and peer support for both students and faculty.

Society of Hispanic Professional Engineers (SHPE) offers social and technical events that promote and enhance the potential of Hispanics in engineering, math, and science.

Minority Scholars Engineering Program (MSEP) is open to all students, and promotes academic excellence, facilitates leadership skills, and fosters a community of engineering scholars.

Promoting Equity in Engineering Relationships (PEERs) teaches students to teach their peers to be change-agents for increased diversity. Students earn internship credit by becoming PEERs leaders and helping with presentations.

Women in Science & Engineering (WiSE) provides social connection, mentoring, advising, and tutoring for women in science and engineering. Programs include academic support, Bridge, the WiSE Conference, and the Pre-Major and Pre-Professional programs.

American Indian Science & Engineering Society (AISES) builds community while bridging science and technology with traditional Native values. Opportunities for American Indians and Native Alaskans to pursue studies in science, engineering, and other arenas.

Society of Advancing Chicanos and Native Americans in Sciences (SACNAS) offers social and technical events that enhance and realize the potential of Hispanics in engineering, math, and science.

SCHOOLS THAT AWARD THE MOST EN GINEERING DEGREES, BY DISCIPLINE

AEROSPACE

1. Georgia Institute of Technology
2. Embry Riddle Aeronautical, Daytona Beach
3. Purdue University
4. Virginia Tech
5. Iowa State University
6. Embry Riddle Aero., Prescott
7. Texas A&M University
8. University of Central Florida
9. University of Maryland, College Park
10. University of Illinois, Urbana-Champaign

BIOMEDICAL

1. Georgia Institute of Technology
2. University of California, San Diego
3. Arizona State University
4. Drexel University
5. Boston University
6. Rutgers University
7. Case Western Reserve University
8. Duke University
9. University of Connecticut
10. Clemson University

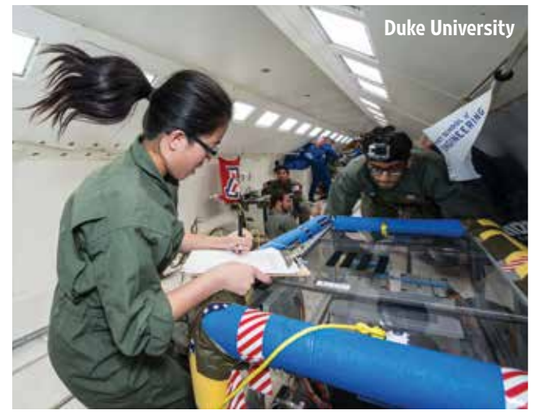
CHEMICAL

1. Georgia Institute of Technology
2. Ohio State University
3. University of California, San Diego
4. The Pennsylvania State University
5. North Carolina State University
6. The University of Texas at Austin
7. Purdue University
8. University of Illinois, Urbana-Champaign
9. University of Colorado Boulder
10. Texas A&M University

CIVIL

1. Texas A&M University
2. University of Illinois, Urbana-Champaign
3. Virginia Tech
4. Georgia Institute of Technology
5. University of California, San Diego
6. Ohio State University
7. California State Poly. State University
8. Pennsylvania State University
9. University at Buffalo, SUNY
10. University of California, Davis


North Carolina State University


Duke University

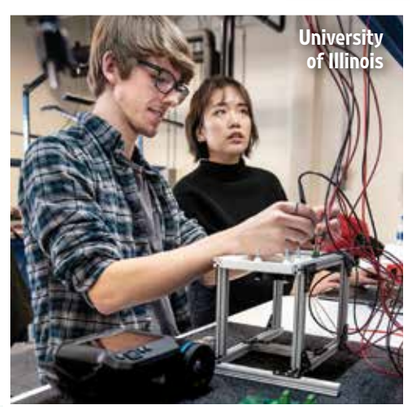

University of Florida


Georgia Institute of Technology


Purdue University


Boston University


University of Central Florida


University of Illinois


University of Texas, Austin

MANUFACTURING & SYSTEMS

1. Georgia Institute of Technology
2. Texas A&M University
3. Purdue University
4. University of Michigan
5. Pennsylvania State University
6. Virginia Tech
7. Ohio State University
8. University of Central Florida
9. University of Florida
10. Clemson University

MECHANICAL

1. Georgia Institute of Technology
2. Iowa State University
3. Virginia Tech
4. The Pennsylvania State University
5. Purdue University
6. University of Maryland, College Park
7. University of Central Florida
8. University of Florida
9. The University of Texas at Austin
10. University of Michigan

ELECTRICAL

1. Georgia Institute of Technology
2. University of California, San Diego
3. University of Illinois, Urbana-Champaign
4. Arizona State University
5. Pennsylvania State University
6. North Carolina State University
7. Purdue University
8. University of Washington
9. University of Central Florida
10. California State University, Long Beach

COMPUTER

1. University of California, Berkeley
2. University of Illinois, Urbana-Champaign
3. Georgia Institute of Technology
4. Iowa State University
5. North Carolina State University
6. San Jose State University
7. Virginia Tech
8. California Poly. State University
9. University of Central Florida
10. Purdue University

ALL PHOTOS COURTESY THE SCHOOLS

NOTE: ALL DATA IS FROM THE 2016-2017 SCHOOL YEAR, LATEST AVAILABLE. SOURCE: AMERICAN SOCIETY FOR ENGINEERING EDUCATION.

DO YOUR OWN THING

If you want to start your own business, a good first stop is engineering school.

In an engineering career, there are always new areas for problem-solving and new settings in which to apply skills. While engineers have options in well-known, large corporate and research organizations, they can also work independently, launching products that come to have a big impact. That's the story of Apple, of course, but also the story of a toy company called littleBits.

Ayah Bdeir is originally from Lebanon, a country with a strong entrepreneurial tradition. She was eager to pursue engineering in college but didn't see herself working in traditional corporate engineering settings. She knew she wanted to do something to show how technology enhances creativity, something that would make technology appealing to people who don't typically see themselves as tech-oriented. People like artists and...children.

Harnessing engineering know-how to entrepreneurial drive, Bdeir invented littleBits, electronic components that children put together to invent machines that work to do whatever they decide they want a machine to do — blink, beep, blow bubbles, and more! The component bits are high-tech building blocks allowing kids to decide what to build and then figure out how to build it. The company keeps expanding offerings: kids can now construct a robotic gripper arm, customize a synth guitar into hands-free air drums, or build a space rover. There's even a kit that helps kids learn how to code, one of the basics for engineering in cyberspace.

The littleBits kits have earned more than 150 awards in tech, education, and toys — including The Toy Association's 2018 Creative Toy of the Year—and have sold in the millions in over 70 countries. And kids keep finding new way to be creative with the products: more than 1.5 million projects have been uploaded to the DIY community in subjects such as astronomy, pizza making, and woodworking!

Bdeir's primary focus has always been on getting littleBits into schools, so that kids of all income levels have access to them. Over 2000 schools now make playing with littleBits part of what Bdeir hopes will become life-long learning and life-long imagining in the best tradition of engineering!

COURTESY LITTLE BITS

IN DEMAND ... AND WELL PAID

Engineers work at large corporations and established small businesses. They start high-tech companies that power the nation's economy and can also be found in government agencies. Here are examples of where engineers from different disciplines work.

AEROSPACE
BAE Systems, Boeing, Department of Defense and Energy, Lockheed Martin, NASA, Northrop Grumman

AGRICULTURAL
John Deere, Kellogg's, Monsanto, Weyerhaeuser

BIOMEDICAL
Boston Scientific, Eli Lilly, Genentech, Medtronic, Merck, Pfizer, Siemens Medical Solutions

CHEMICAL
Bayer, Chevron, DowDuPont, General Mills, Procter & Gamble

CIVIL
Bechtel, CH2M Hill, CSX, Department of Transportation, Southern Co., U.S. Army Corps of Engineering

COMPUTER
Apple, Cisco, Department of Defense, Electronic Arts, IBM, JPMorgan Chase, root9B, Sophos, Symantec

ELECTRICAL
Dassault Systèmes, General Electric, Google, Intel, Raytheon, Xilinx

ENVIRONMENTAL
Environmental Protection Agency and Department of Interior, Roux Associates, Sierra Club, Veolia

MANUFACTURING
General Dynamics, Illinois Tool Works, Toyota, UPS

MATERIALS
Alcoa, General Motors, Kimberly Clark, Nike, 3M, Under Armour, Unilever

MECHANICAL
BMW, Caterpillar, Ford Motor Co., General Motors, Walt Disney World

MINING & PETROLEUM
Apache Corp., Chevron, Exxon Mobil, Ingersoll-Rand, Phelps Dodge, Schlumberger, Shell Oil, Tesoro

NUCLEAR
Babcock & Wilcox, Constellation Energy, Los Alamos National Lab, Westinghouse Electric

OCEAN
Coastal Planning and Engineering Inc., Deep Ocean Engineering, Far Sounder, Hatch Mott MacDonald

SYSTEMS
FedEx, Rockwell Automation, Royal Caribbean, United Airlines

Engineering graduates across disciplines are among the highest-paid students coming out of college. They often command salaries significantly higher than other undergraduates. For 2017, engineers' salaries were 30 percent higher than the average salaries of all majors.

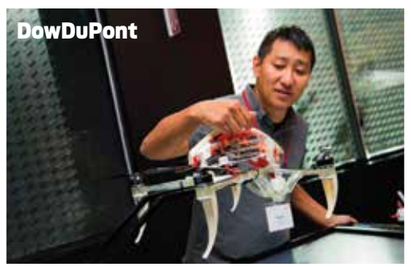
AVERAGE SALARIES 2017

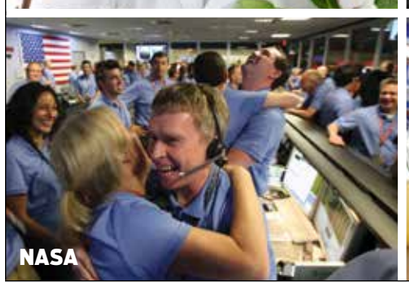
DISCIPLINE	STARTING SALARY
Computer Science	$73,677
Engineering	$65,539
Math & Science	$60,631
Health Sciences	$53,872
Business	$52,456
Overall Average	$50,516
Social Sciences	$46,707
History	$38,997
Communications	$38,897
Visual & Perf. Arts	$37,887
English	$36,180

TOP-PAID ENGINEERING MAJORS 2017

MAJOR	STARTING SALARY
Computer Engineering	$76,070
Petroleum Engineering	$73,084
Electrical Engineering	$72,930
Systems Engineering	$69,432
Materials Engineering	$68,449
Mechanical Engineering	$66,519
Chemical Engineering	$66,490
Industrial Engineering	$64,904
Aerospace Engineering	$64,699


Bayer


DowDuPont


NASA


Boeing


Shell Oil

Under Armour


Dept of Defense

Start Engineering

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If you'd like to purchase more guide books, go to: http://start-engineering.com/shop/

SOURCE: AMERICAN SOCIETY FOR ENGINEERING EDUCATION AND THE NATIONAL ASSOCIATION OF COLLEGES AND EMPLOYERS

ALL PHOTOS COURTESY THE COMPANIES OR ORGANIZATIONS

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(Spoiler alert: This is you at the finish line.)

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