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THE MAGAZINE FOR ENGINEERING STUDENTS

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Dear Future Engineer,

Welcome to another issue of New Engineer!

We would like to congratulate you on choosing a career in engineering – one of the fastest and hottest growing industries.

You've taken the right first step in picking up New Engineer. There are a multitude of sectors and sub-sectors in engineering and to help you make the right choice, we will focus on one in every issue going forward. Our goal is to make it easier for you to figure out where your strengths and interests lie, so that you can choose a course of engineering study that will be a good fit for you! In this issue, we focus on Aerospace and the two main components under that umbrella – Astronautical vs. Aeronautical. Have you wondered what the difference is between the two and what job responsibilities each entails? We've researched everything you need to know, so you don't have to!

This issue also includes an informative and handy tip guide to how beginning structural engineers can succeed in the industry, courtesy of cloud engineering software company, Sky Civ.

We hope you enjoy and learn from New Engineer as much as we did putting it together. Look for upcoming issues to include more feature articles from engineering academics and professionals in their areas of expertise, new and exciting fields, resources, guides and much more!

We look forward to making our publication an invaluable resource for you as you navigate the vast waters of engineering throughout your journey.

Go change the world!

Cathy Demetropoulos
Editor

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DR. FRANCES ARNOLD: PIONEERING BIOENGINEERING AND INSPIRING WOMEN

NOBEL LAUREATE IN CHEMISTRY 2018 & LINUS PAULING PROFESSOR OF CHEMICAL ENGINEERING, BIOENGINEERING AND BIOCHEMISTRY AT CALTECH (CALIFORNIA INSTITUTE OF TECHNOLOGY)

BY: CATHY DEMETROPOULOS

Dr. Frances Arnold is a woman in engineering to truly be inspired by. Of course, being the daughter of a nuclear physicist set some expectations for her, however, Dr. Arnold hasn't ridden on anyone's coat tails; she has far exceled in her field in her own right. This year, she became the recipient of the highly prestigious Nobel Prize in Chemistry for pioneering the use of directed evolution to engineer enzymes.


Dr. Frances Arnold

"[As a child] I was always making things and was very good at and loved math - especially geometry - and puzzles. And I was always interested in technology. My father was a nuclear physicist who revelled in the scholastic achievements of his children and encouraged us all equally." Her illustrious career path began in 1979 when she received her B.S. degree in mechanical and aerospace engineering from Princeton University and went on to receive her Ph.D. in chemical engineering from the University of California, Berkeley, due to her deep interest in biochemistry.

Although it's clear why she chose to pursue a career in engineering, we were interested in what turned her on to biotechnology, specifically. "I studied mechanical engineering and worked on solar energy at the Solar Energy Research Institute after graduating from Princeton but the industry's prospects changed for the worse in the early 1980s and I decided to do my Ph.D. I had initially intended to work on biofuels but I stumbled on this new field of biotechnology. The ability to engineer the most complicated things on our planet – biological systems – was too much of a draw to ignore."

She explains her prize-winning method of directing the evolution of enzymes as breeding, similar to mating cats or dogs to bring out desired traits, but at the level of molecules. The aim is to create new and better biological material in the form of enzymes, which are proteins that catalyse chemical reactions.

Dr. Arnold is one of two female winners of the Nobel prize this year, which is extraordinary and speaks to the Nobel Foundation's efforts of asking nominators to be more inclusive of women and ethnic minorities. More so, Dr. Arnold attributes this to the facts: that there are women doing fabulous things in physics and chemistry. "I predict this is the beginning of a steady stream," she says confidently. "To get the prize, you first have to be nominated. And that means someone has to care enough about you to take the time to explain your science to someone else. Men often have a good network of people who are willing to do that for them. Women need to cultivate those networks and often they are not as pushy about that as some of the men are. We have to learn how to be pushy or at least ask and I am gratified to see that my younger colleagues are starting to do that."

As for young women who are interested in a career in science and engineering, she has one simple and effective piece of inspirational advice:

Don't leave this fun work just for the men to do.

Reading Between the Lines

What they *really* mean when they say...

"SEEKING CANDIDATES WITH A WIDE VARIETY OF EXPERIENCE"
You'll need it to replace three people who just left.

"REQUIRES TEAM LEADERSHIP SKILLS"
You'll have the responsibilities of a manager, without the pay or respect.

"NO PHONE CALLS PLEASE"
We've filled the job; our call for resumes is just a legal formality.

"JOIN OUR FAST-PACED TEAM"
We have no time to train you.

"APPLY IN PERSON"
If you're old, fat or ugly you'll be told the position has been filled.

"MUST HAVE AN EYE FOR DETAIL"
We have no quality control.

"DUTIES WILL VARY"
Anyone in the office can boss you around.

"GOOD COMMUNICATION SKILLS"
Management communicates, you listen, figure out what they want and do it.

"MUST BE DEADLINE ORIENTED"
You'll be six months behind schedule on your first day.

"SOME OVERTIME REQUIRED"
Some time each night and some time each weekend.

"COMPETITIVE SALARY"
We remain competitive by paying less than our competitors.

MESSAGE FROM THE DEAN

The School of Informatics, Computing, and Engineering (SICE) at Indiana University Bloomington was established in 2000 with an eye on meeting the needs of a world that was charging headlong into the digital age and creating a tomorrow that brings people closer together with each advancement.

Nearly a generation later, we continue to inspire, teach, and develop the technology that will drive innovation for years to come. Our new Intelligent Systems Engineering program (ISE) is focused not on what engineering has always been but what it will be. ISE recasts and refines traditional engineering curricula to incorporate the most current technologies, practices, and philosophies. The sensors and small-scale, networked devices that provide so much data for our information-driven world are designed by intelligent systems engineers, and they are clearing the path for developments that will allow us to meet the challenges for improved healthcare, a better environment, and much more.

The opportunities afforded to students in SICE allow them to build the kinds of experience inside and outside the classroom that will prepare them to make an impact in their chosen career from day one.

Our School is a unique blend of traditional programs with a visionary twist and world-class faculty who are leaders in their field. The opportunities afforded to students in SICE allow them to build the kinds of experience inside and outside the classroom that will prepare them to make an impact in their chosen career from day one, and our dedication to providing resources for our students to excel is unparalleled.

Whether it be undergraduate research opportunities, modern teaching techniques, building communities that foster collaboration, or providing the state-of-the-art facilities that allow students to reach their potential, the School of Informatics, Computing, and Engineering is focused on engineering a better tomorrow.

Our vision will help students reach their dreams, and we hope you enjoy a look at some of what our School has to offer.

Raj Acharya

Dean, School of Informatics,
Computing, and Engineering
Rudy Professor of Engineering,
Computer Science, and Informatics

COVER STORY

Forward Thinking:

Building the future at Indiana University.

When the Intelligent Systems Engineering program at the Indiana University School of Informatics, Computing, and Engineering was established in 2016, the focus was on creating a forward-thinking program. The curriculum was designed from scratch—allowing for a blend of traditional engineering concepts and modern perspectives—and degrees were offered at both the bachelor's and Ph.D. levels.

The gap between those two degrees has been filled.

IU is now offering a Master of Science in Intelligent Systems Engineering degree, providing graduate students with the technical breadth they need for the fast-changing world of technology. The focus of the program is on intelligent, connected systems that are becoming ever more abundant, including the sensors that make our devices "smart" and the massive systems that analyze the

f ood of data all around us. The program also emphasizes artificial intelligence and machine learning that provide the underpinnings of the technology of the future.

"Our intelligent systems engineering program is unique because we're so focused on how we can use technology to build the world to come," said Raj Acharya, dean of SICE. "The addition of a master's degree will allow us to build on the existing strengths of IU in science and technology, informatics and computing, biology, chemistry, physics, psychological and brain sciences, environmental science, health, and so many other fields to provide a quality, comprehensive education that will prepare our students for whatever career they may pursue."

Students in the M.S. in ISE program have the option of selecting one of six tracks—including bioengineering, computer engineering, cyber-physical systems, environmental engineering, molecular and nanoscale engineering, and neuroengineering—all of which provide the opportunity for cutting-edge innovation that will shape tomorrow.

Bioengineering

The bioengineering track meets at the intersection

of biology and technology, and it will help improve healthcare and provide a better understanding of everything from biological systems down to nanoscale devices.

Bioengineering at SICE also includes biomechanical engineering, which utilizes bioimaging and sensor devices in biomedicine and healthcare, and it focuses on the interface between biological systems that produce biochemical and optical signals, and electronic systems that deal with electrical systems.

Computer Engineering

The computer engineering track focuses on everything from building more efficient networks to making computer hardware smaller and faster. Creating more efficient software is also a goal.

As computing needs expand, the improved use of resources is critical to allow private industry and academia to get the most out of their hardware and software. Computer engineers are in demand in many sectors, and developers of the embedded systems, computer architectures, computer network technology, power and energy usage for large-scale computing systems, robotics, and more are needed to meet the goals of users.

SICE already has a well-respected reputation in computing through some of its research centers, and students will have the opportunity work alongside Ph.D. students and world-renowned faculty to build a smarter and more mobile world.

Cyber-physical Systems

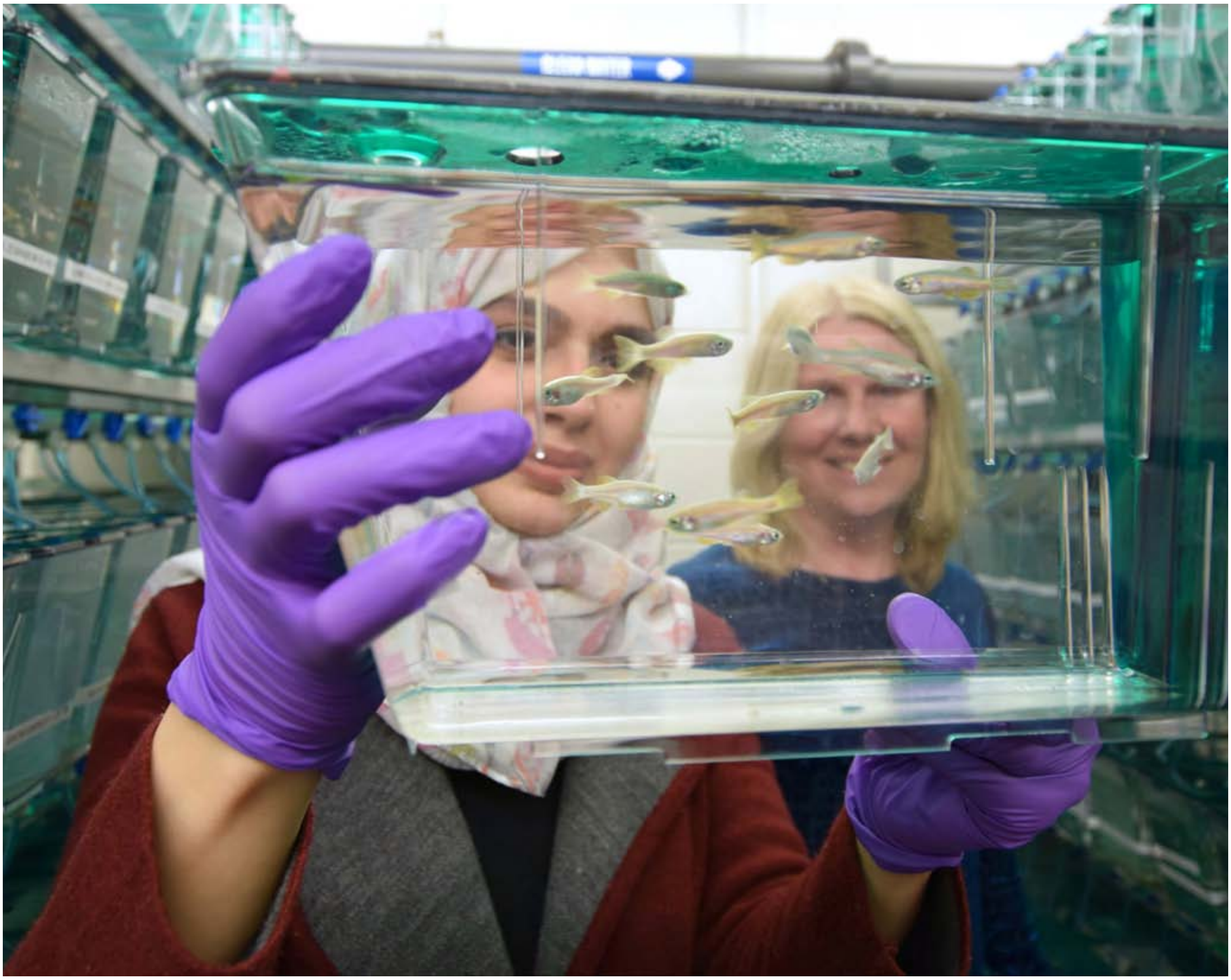
Students interested in cyber-physical systems track learn to combine physical components of computing with computer algorithms to create a seamless experience for users.

Most students and the general public are already familiar with cyber-physical systems, although they may not know it. Everything from using a GPS system for navigation to connecting to a Bluetooth speaker requires a cyber-physical system, but the field goes far beyond that. CPS is part of the Internet of Things, which allows sensors and smart devices to interact with our world while also providing the means for data to be collected and acted upon.

Cyber-physical systems form the basis for the development of self-driving cars, improved communication systems, more advanced touch screens, robotic and autonomous farming, and more. Cyber-physical systems are embedded in our daily lives, and students will gain knowledge and experience while positioning themselves on the cutting edge of innovation.

Environmental Engineering

SICE's environmental engineering track brings together biology, chemistry, engineering, and technology to find solutions to some of the biggest environmental issues facing our world.



Studying the impact of global climate change is a focus, as is everything from using drones to measure concentrations levels of CO_2 to finding more efficient methods of recycling to predicting environmental outcomes. Environmental engineers find themselves on the frontlines of studying the impact of pollutants on public health and the environment, and students use an interdisciplinary approach to combine technology and life sciences to improve outcomes for future generations.

Environmental engineers also find themselves in one of the most in-demand fields, and they can fill a variety of occupations that provide an opportunity to work both in an office setting or in the field studying the environmental conditions of wetlands, construction sites, forests, urban environments, and everything in between.

Molecular and Nanoscale Engineering

SICE's molecular and nanoscale engineering track integrates concepts from materials engineering with nanoscience to prepare students to work with cyber-physical systems or other responsive intelligent systems that include nanoscale building blocks. The study of molecular and nanoscale engineering provides the foundation for the development of "smart" materials that can probe biological processes, improve food science, create new modes of energy production, and more.

It also teaches students how to translate advances in physics, chemistry, biology, and the computational sciences into functional tools. For instance, molecular and nanoscale engineering can create the methods and materials to fight disease at the molecular level, which can improve healthcare and create better and healthier outcomes for patients.

Both molecular and nanoscale engineers are in high demand, and they are needed in an array of industries. Research opportunities abound at SICE, and master's students will earn the experience of working in a group setting on projects that are designed to mirror a real-life work environment.

Neuroengineering

Neuroengineering is another track offered to M.S. in ISE students. This exciting field allows students to pursue the cutting-edge field of using technology to study living neural tissue and create technology to measure, repair, or replicate the functions of the brain.

For instance, neuroengineers could create micro-scale devices that can connect neurological functions to technology to allow sensors to detect impending seizures, or they can create systems to better understand the underlying foundations of memory creation and retention. Students will also learn the concepts that could lead to the physical repair of the brain or the development of replacement parts for the nervous system, which could lead to advances for patients suffering from neurological disorders or paralysis.

Flexible Degree Path

Students in SICE's master's in ISE program have the f exibility to create their path to a degree by following a selection of four paradigms on how they want to learn. They can focus on coursework, incorporate internships into their learning, focus on a project, and/or follow a research path that can build experience.

"There are a lot of options as part of the master's degree," says Paul Macklin, an associate professor whose focus is on understanding and modeling the behavior of cancer cells. "There are coursework options and thesis options for students. We involve students in research at the school all the way from a student's freshman year, and our master's students will certainly have the opportunity to benefit from the robust slate of research that is being conducted at SICE. It's really up to the student to choose the path that best suits them."

The program requires 30 credit hours and can usually be completed in two years. Students in the program come from all over the world, and some classes use streaming and online elements that provide some f exibility in classes.

"What's special about our ISE master's program is that it consists of such a wide range of specializations that allow students to mold their own path," says Minje Kim, an assistant professor of ISE and one of the key advisors of the program curriculum. "Everyone isn't taking the same classes to arrive at one goal. There is some freedom to where you want to go. You can become a certain level of expert in different fields, and you can make a real impact on the research that is being conducted in those fields."

State-of-the-art Labs

The various labs at SICE also afford students the opportunity to work with state-of-the-art technologies that will prepare them for their careers to come. Luddy Hall, SICE's new $39.8 million home, features five labs dedicated to intelligent systems engineering, and the nearby Multidisciplinary Engineering and Sciences Hall is undergoing renovations to include more lab space for the program.

"Our research facilities at SICE are huge assets, and there are a wide range of them," Kim says. "Students have access to a variety of resources as part of our courses, and it allows them to learn some hands-on engineering methods, techniques, and concepts. Our learning isn't just in the classroom or as part of a book. Our curriculum allows students to learn by doing, which is one of the core concepts of the program. For instance, our students have access to some of our supercomputing capabilities, and they love the opportunity to use cutting-edge technology to work on research or even their homework. And our facilities are continuing to improve and expand. It's a program that is really building for the future."

Fishing for Toxins

Maria Bondesson, an associate professor of ISE, studies the environmental impact of toxic chemicals and compounds using zebrafish. Bondesson and her students use genetically altered specimens to study how the chemicals and compounds impact the development of embryonic zebrafish, allowing researchers to gain insight into how such substances interact with the environment.

"If you want to study things in the traditional sense using mice or rats, it's going to take ages and cost enormous amounts of money," Bondesson says. "That's why there is a backlog in chemical testing. It's too expensive and too low-throughput. We're creating alternative screenings, such as fish or fruit f ies or C. elegans, which is a small nematode, which allow us to build models to speed up testing. By creating a high-throughput study that is cheaper and faster, we can arrive at results that could alert people to dangers that might exist in some chemicals and compounds."

Bondesson says master's students in the bioengineering track will have the opportunity play a role in critical research while gaining experience that will make a student more attractive to a potential employer or provide the foundation for future academic study.

"Master's students can take part in one of the sub-projects we're working on," Bondesson says. "I have a Ph.D. student who came up with the idea of studying e-cigarette liquids in our fish to see what perturbations we see during their development. That is a small sub-project, but it's an important one, and they can take part in such a study. They also could work on image analysis projects. It depends on if the student is more into bioengineering or computation. There are a lot of options."

Have You Thought About a Career as an Engineering Project Manager?

Technical project management skills are in high demand, regardless of your engineering field.

Many undergraduates may not be considering a career as an Engineering Project Manager as they prepare to graduate since many are focused on finding a more traditional role within their chosen field of engineering. However, many, if not most, engineers end up working on projects of some type, whether they are relatively simple efficiency improvements, multiple-year, large-scale construction projects, or high-technology complex cell phone products. The author Hans Thamhain (2014) quotes Jeff Bezos, founder and CEO of Amazon.com saying "What gets us up in the morning and keeps us here late at night is technology, advanced technology is everything." Thamhain goes on to add "However, the vehicle for transforming this technology into marketable products and services is project management" (p. 19). Hence, longer term the challenges and rewards of engineering project management lure some engineers away from more traditional engineering positions. Yet, many undergraduate engineering degree programs don't prepare their undergraduate engineering students to be project managers. Yes, they may get some ad hoc project management experience working on their school's Formula race car team or concrete canoe team, but rarely do they receive any formal project management training.

Yet, many graduates find that as soon as they start their well-earned job with their first full-time employer they quickly get involved in projects. While their undergraduate education prepares them well to handle the technical aspects of their new position, they often find that they don't fully understand why some projects seem to go well, while many others seem to founder, if not outright fail. Many organizations don't provide any formal training to their young engineers on how to manage projects successfully. They are left to try to interpret their experiences, and their interactions with the more senior engineers that they work with, to discover what makes a project a success or a failure.

Results from a study by the Project Management Institute (2016) identified that $122 million was wasted for every $1 billion invested due to poor project performance in 2016 (p. 5). In this report, Bill Seliger, PMP, Director, Supply Chain and Project Management for a Fortune 500 manufacturing company stated: "Without a doubt, good project management drives more success, lowers the risk, and increases the chance of success for delivering the economic value of the project" (p. 8). The study also showed that organizations that invest in project management training see a significant improvement in project success (p. 11).

The PMI Talent Triangle™ identifies three areas of expertise that are required for effective project management: technical project management, leadership, and strategic and business management. The PMI study stated that when organizations focus on all three areas 40 percent more projects meet original goals and business intent. In addition, improvements in managing budget, time, scope creep, and projects deemed failures are also realized (Project Management Institute, 2016, p. 10). Engineers can learn some of the technical project management skills by working with experienced senior engineers, but they are much less likely to learn solid leadership and strategic and business management skills. Unless the senior engineer has received formal project management training, they are also less likely to learn about all of the project management tools that their projects could potentially benefit from.

During the early portion of my career, I managed many small projects, from short, one-month projects to improve the quality of a part that we were purchasing from a supplier to many month projects to introduce new test fixtures to reduce testing time on our assembly line. I sure would have benefitted from project management training. Unfortunately, I was never offered any training and project management training wasn't nearly as readily available back then as it is today. While many of the projects that I worked on were successful, they certainly could have been done more efficiently and others might have been more successful if I had known about the tools and techniques available by using a formal project management process. In particular, my projects would have benefitted from a more formal communication plan, better stakeholder identification and management, and some thought about risks, risk management, and risk mitigation. I have found that many organizations don't have any formal process to address project risks, yet the unidentified risks on a project are often the cause of failure on a project.

Think about the projects that you have done as part of your undergraduate program. Did you formally address the risks associated with your project? Were you successful in finishing each of your projects on time, on budget (at least in terms of how much you had to put into them), and at the quality level that you, and your professor, were satisfied with? If not, then you might want to seriously think about taking some formal training in the field of project management. The skills and knowledge that you gain will help you bridge the fields of engineering, technology, people, and business to successfully deliver projects for your new organization.

So where can engineers receive formal project management training? First, as an undergraduate student watch for an opportunity to take an introductory project management course as part of your degree program. Some schools may even offer an intersession course in project management. Once you start your new job ask about whether or not your new organization offers any project management training. If they do, sign up for what is offered as soon as possible, as the earlier that you receive formal training the sooner your career and your organization will benefit from it.

If your new organization doesn't offer any formal training, then you will have to look for other sources. Local colleges and universities may offer training in project management, either as a graduate degree program, a certificate program, or through continuing education offerings. A number of high—quality online project management degree and certificate programs are also available through colleges and universities. Check out whether or not your new employer offers any tuition assistance and what courses/programs they will reimburse for. Many companies will only provide tuition reimbursement for an approved degree program, but others will pay for certificate programs or individual courses as well. There are also many other sources of project management training available, but I would recommend that you do some research before signing up for one to make sure that you are enrolling in a high-quality program. It would be wise to look for a program with qualified instructors, particularly those with lots of experience in applying project management principles to real-world projects. You should also look for a program that offers f exibility in the format and availability of courses, one that utilizes well-respected instructional materials, and one that offers the opportunity to interact with other students and the instructors. This last point is important, even though the quality of the instructor and instructional materials is important, in a high-quality program you will also learn a considerable amount from your interaction with the other students as they share their experiences and applications of the principles that are studied. Also, check out your local chapter of the Project Management Institute, as most local chapters offer various professional development opportunities and they also offer many opportunities to network with other project managers.

Congratulations on your upcoming graduation, it is well deserved given the hard work that you have undertaken to earn it. Good luck in your new organization as you embark on this exciting new chapter in your life. I will leave you with best wishes for many project successes throughout your career.

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EST ENGINEERING

10

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12

SPACECRAFT

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INTERNET

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HEALTH TECHNOLOGIES

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PETROLEUM & PETROCHEMICAL TECHNOLOGIES

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LASER & FIBER OPTICS

18

NUCLEAR TECHNOLOGIES

THE 20TH CENTURY

INDUSTRIAL AND SYSTEMS ENGINEERING

USC Viterbi Professor of Industrial and Systems Engineering James E. Moore, II has served as a Department Chair, Vice Dean, and as President of the Institute of Industrial and Systems Engineers (IISE), the field's lead professional society. He agreed to answer a few questions from New Engineer about the field of industrial and systems engineering, and the opportunities it presents for students.

What is the field of industrial and systems engineering about? What kinds of problems do industrial engineers solve, and for whom?

The Institute of Industrial and Systems Engineers defines the field as "the design, improvement and installation of integrated systems of people, material, information, equipment and energy. It draws upon specialized knowledge and skills in the mathematical, physical and social sciences together with the principles and methods of engineering analysis and design to specify, predict and evaluate the results to be obtained from such systems." This is the long answer.

The short answer is that industrial and systems engineering is a blend of engineering and management science.

Other engineering disciplines are known for the products they design. Industrial and systems engineers are known for the systems they design and improve. These system improvements tend to increase quality, reduce costs or both.

Can you provide some examples of the problems and the sort of work in which industrial and systems engineering graduates become involved?

The field is versatile with respect to the nature of work done and the industries in which it is done. Industrial and systems engineers are in demand in almost every sector of the economy, but most strongly in sectors involving large-scale integrated systems, including logistics and distribution, hospitals and health

"NO ENGINEERING FIELD CAN CLAIM AN INTELLECTUAL MONOPOLY ON SYSTEMS OR SYSTEMS THINKING..."

care, enterprise resource planning, aviation, aerospace, energy and resource extraction, manufacturing, the military, and other systems-oriented activities. There are also excellent opportunities for industrial and systems engineers in consulting and engineering services, information technology, research and development, and nonprofits. The sort of job activities in which industrial and systems engineers might be involved include risk assessment, process validation, project engineering and execution, systems integration, instrumentation, quality and reliability, facilities layout and design, or any aspect of process improvement.

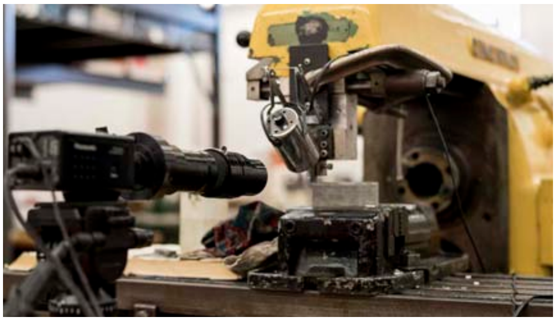
Are industrial engineering and systems engineering different, and if so how?

No engineering field can claim an intellectual monopoly on systems or systems thinking, and the "industrial and systems engineering" label does not imply one. Most engineering activities pertain in some way to the creation, improvement, better understanding of or use of a system--some set of elements that operate collectively to produce specialized outcomes. Systems engineering, in the broadest sense, focuses on enabling the successful functioning of a system, and in this sense any engineering project in any discipline might qualify as an exercise in systems engineering. There is in the Department of Defense arena a fairly narrowly defined version of systems engineering that focuses on a development cycle for systems acquisition, including software systems. It is more meaningful to think of systems engineering as an interdisciplinary, integrative activity, most often team-based, that defines the process for bringing a successful system to realization

Industrial and systems engineers are as interested in the system itself and its functions as in the nature of the process that brings it about. Industrial engineers and systems engineers both rely on a systems point of view that emphasizes understanding and managing trade-offs associated with system design, but a purely systems engineering approach is more likely to be driven by functionality requirements, with top-level functions taken as given requirements and the resources necessary to produce a validated system capable of executing these functions treated as an internal result. Industrial engineering approaches are more likely to treat resources as given constraints, because they are scarce; and system performance as an internal function of design; and focus on maximizing performance. Both approaches involve a refined capacity for systems thinking. Industrial and systems engineering is a powerful blend of these complimentary approaches.

When was the field of Industrial and Systems Engineering founded?

The first academic department of industrial engineering in the United States is Penn State's Marcus Department of Industrial and Manufacturing Engineering, which was established in 1908. This was a pioneering step. The Institute of Industrial and Systems Engineers was not established until 1948. There were no doctorates granted in the field until Purdue University granted the first two in 1949.



You said industrial and systems engineering is a blend of engineering and management science. Isn't management science part of business administration?

Management is an important business function, but management extends beyond business. All scarce resources are subject to management by the decision makers in charge of them, environmental quality, public health, infrastructure, information, intellectual property, capital (financial, human, social), inventories, supply chains, distribution networks, physical plant facilities, productive capacity... The list is endless.

What are the differences, then, between an industrial and systems engineering degree and a degree in business administration?

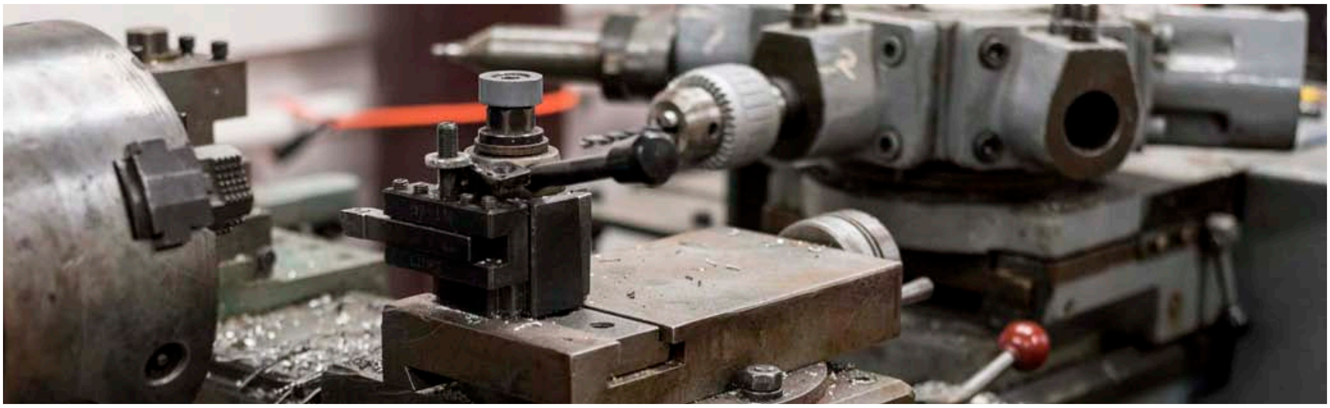
There are some schools where industrial and systems engineering is actually embedded in a business school, but this is not ideal. The difference between these degrees is mostly one of methodological depth versus breadth, and of focus. An undergraduate degree in industrial and systems engineering is methodologically deeper and narrower than the curriculum for an undergraduate business degree. An ISE degree is an engineering degree with all of the basic science, math and engineering science content typical of any undergraduate engineering degree. The two years of calculus that undergraduate engineering students complete are leveraged rather heavily in the more advanced courses in industrial engineering programs, which typically place a strong emphasis on statistical thinking, systems modeling and reliability, simulation and optimization. The math sequences for industrial and systems engineering and computer science students often include an elevated emphasis on discrete mathematics, because both fields include a focus on algorithms.

An undergraduate business curriculum is less invested in the use of mathematics to structure approaches to important problems, and includes coursework relating to business functions that an ISE program typically would not, such as marketing. While industrial and systems engineering programs tend to be narrower and deeper than business programs, they also tend to be broader than most other engineering programs, typically including coursework in areas such as economics, industrial psychology and organizational behavior.

Industrial and Systems Engineering is at its core a set of engineering methods applied in the context provided by of a systems view of process design, improvement, and control; and this perspective takes the field in directions that a business program typically would not go. For example, human factors engineering, cognitive engineering, human/computer interfaces, ergonomics, product design and manufacturing are all problem areas within industrial and systems engineering that typically would not be represented in business curricula at either the graduate or undergraduate level.

Is the industrial and systems engineering major popular?

It is relatively popular. The American Society for Engineering Education reports that, nationally, the field produced just under 5,700 bachelor's degree graduates in 2016, a total just a little lower than biomedical engineering, and about 50% higher than aerospace engineering, the next largest discipline. Many of these graduates transferred into the field only after starting college.



Why do you think so many undergraduates gravitate toward ISE?

The ISE cohort at most schools grows as undergraduates gain academic experience and refine their judgements. Engineering is defined by very strong undergraduate programs. I think engineering education is the best undergraduate education that universities offer. Engineering programs are defined by the various department faculties. These scholars are deep experts in their respective fields, and the programs they create are excellent options for any qualified student. However, there is no reason to expect that every new undergraduate who starts engineering as a freshman will really know enough about the array of options available to him or her to have made the best choice of major on the first try, regardless of how conscientious, intelligent, or motivated he or she is.

College is about growth and developing an understanding of the world and oneself, and this is naturally going to lead most students to examine and possibly reconsider their academic paths at some point. Because industrial and systems engineering is the broadest of the undergraduate engineering majors, every student who explicitly considers the trade-off between breadth and depth and concludes that a better education favors breadth is going at least consider making a transition into industrial and systems engineering.

Some adjustments are inevitable, and so the field of industrial and systems engineering is made up mostly of intellectual immigrants. This demonstrated capacity to recognize when an adjustment is needed and what it should be helps make industrial and systems engineering graduates consummate economic competitors.

Is the field attractive at the graduate level?

Industrial and systems engineering is particularly attractive at the graduate level. There are really two relevant graduate degree categories, industrial and systems engineering, including operations research and manufacturing degrees; and engineering management degrees. Engineering management stands alone as a graduate option at a few institutions, but most often the degree is mounted by an industrial and systems engineering department, typically as a terminal professional degree. If you combine the number of masters degrees awarded nationally in these two areas, the total is just slightly below the total number of master's degrees awarded in mechanical engineering, and 25% than the total number of masters degrees awarded in civil and environmental engineering combined.

Students pursuing graduate degrees in industrial and systems engineering or engineering management very frequently have undergraduate backgrounds in technical areas other than ISE. This is useful, because it keeps the discipline intellectually vibrant and interdisciplinary as graduate students drawn from outside the field infuse industrial and systems engineering methods into new kinds of problems.

This situation also persists in part because engineering management degrees are a very compelling alternative to the MBA degree for engineers who want to pursue management responsibilities in a technical arena. Graduate degrees in engineering management typically are only half as long as an MBA program.

Do you have any closing thoughts?

There is only one person in the audience when a student chooses an academic major, him- or herself. A student has absolutely no one else to answer to in this choice, no one else to be accountable to, because it is the student who will live his or her life. Recognizing the need to make an adjustment if and when the need emerges is not evidence that prior decisions were in any way inferior. A capacity to adjust is part of the capacity to succeed.

Author's information:

James E. Moore, II

Professor of Industrial and Systems Engineering

USC Viterbi

THE WORLD'S STRANGEST LAWS

In Vermont, women must obtain written permission from their husbands to wear false teeth.

It is an act of treason to place a postage stamp bearing the British monarch upside down.

Under the UK's Tax Avoidance Schemes Regulations 2006, it is illegal not to tell the taxman anything you don't want him to know, though you don't have to tell him anything you don't mind him knowing.

In Alabama, it is illegal for a driver to be blindfolded while driving a vehicle.

In San Salvador, drunk drivers can be punished by death before a firing squad.

In Florida, unmarried women who parachute on Sundays can be jailed.

In the UK, a man who feels compelled to urinate in public can do so only if he aims for his rear wheel and keeps his right hand on his vehicle.

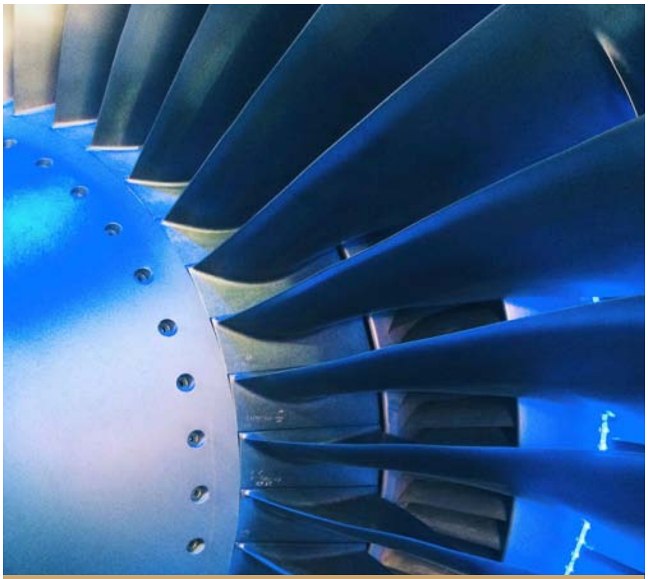
In Boulder, Colorado, it is illegal to kill a bird within the city limits and also to "own" a pet – the town's citizens, legally speaking, are merely "pet minders".

In Kentucky, it is illegal to carry a concealed weapon more than six-feet long.

Did you know it's illegal in France to name a pig Napoleon? Or that in Ohio you're not allowed to get a fish drunk?

AEROSPACE ENGINEERING:

AERONAUTICAL VS ASTRONAUTICAL



THE TERM "AEROSPACE" MAY SOUND MISLEADING; THIS IS NOT JUST ABOUT THE ENGINEERING THAT INVOLVES WHAT'S IN OUTER SPACE. THE DISTINCTION BETWEEN ITS TWO MAIN BRANCHES (AERONAUTICAL AND ASTRONAUTICAL) ORGANICALLY CAME ABOUT WITH THE ADVANCEMENT OF TECHNOLOGY.

Do you have an affinity for how things work above us, way up in the air? In our skies? In outer space? Are you curious as to what's up and out there, how it got there, how it all works and why? Then you may want to consider a career in aerospace engineering.

Aerospace engineers research, design, develop, test and maintain everything from civil and military aircraft and weapons systems to missiles, satellites and space robots or vehicles as well as the work and intricacies that make up every component of these systems. Furthermore, they can specialize in areas such as aerodynamics, structural analysis, manufacturing, systems integration, propulsion, avionics and materials and structures. These specialized areas eventually become connected and the interaction between these technologies and the expertise behind them is the basis for aerospace engineering.

The term "aerospace" may sound misleading; this is not just about the engineering that involves what's in outer space. The distinction between its two main branches (aeronautical and astronautical) organically came about with the advancement of technology. In the past, aerospace engineering was the original term for this field. As technology advanced by leaps and bounds in the past several decades, specifically as it pertained to advancements made in spacecraft and space exploration, aerospace branched off to include the emerging field of astronautics, thereby creating two separate fields: aeronautical and astronautical.

Aeronautical engineers learn about the practice and technology required to f y aircraft and other vessels such as airplanes and helicopters. They design for

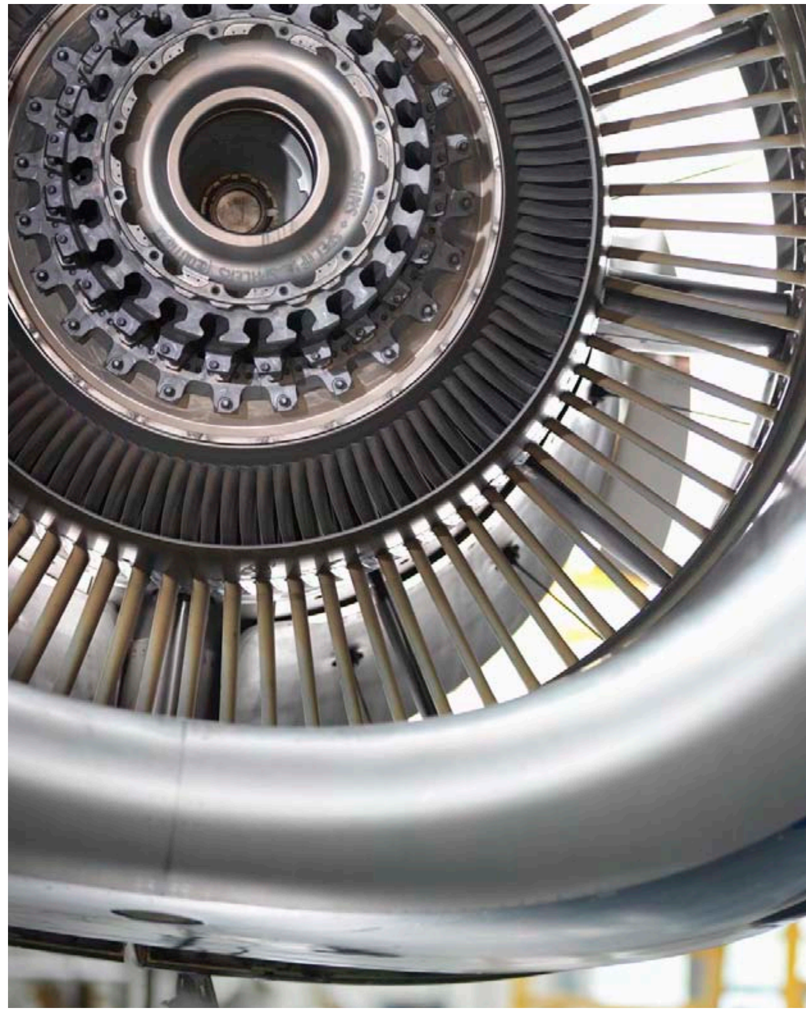
CHOOSING IS AS EASY AS ROCKET SCIENCE

COVER STORY

continued

Aerospace engineers rely on an interdisciplinary mix of mechanical, electronics and materials engineering knowledge. The job responsibilities of aerospace engineers begin with research and development of materials and design specifications, the latter of which can be done learning and using CAD (computer aided design) software

THE ELEMENTS OF AEROSPACE ENGINEERING OVERALL ARE NUMEROUS AND VARIED.



data processing managers, inspectors and compliance officers, or working for commercial aircraft companies such as Boeing or Airbus.

Astronautical

As an astronautical engineer, you will use your technical, practical and expert scientific knowledge to design, develop, research, test, correct, maintain, alter and/or upgrade advanced complex space engineering solutions. These include rockets, space shuttles and capsules, satellites, space launch vehicles and planetary probes. Within the realm of astronautical engineering, you may decide to focus on one of several specialty support roles such as software engineer, spacecraft design, propulsion systems structural engineer or electrical engineer. Astrodynamics or space weather are other concepts you can focus

on in a supportive role to the overall astronautical field. Potential jobs in this field can range from working for an R&D center to spacecraft manufacturing companies, space agencies or executive agencies that focus on scientific research and engineering projects. And of course, who wouldn't want to work for NASA?

Regardless of which branch you choose, aerospace engineers rely on an interdisciplinary mix of mechanical, electronics and materials engineering knowledge. The job responsibilities of aerospace engineers begin with research and development of materials and design specifications, the latter of which can be done learning and using CAD (computer aided design) software. Engineers must apply basic and advanced principles of science and technology to create aircraft, missiles, satellites and such, as well as their components and support systems.

They must also maintain their designs to ensure full operation such as inspections, troubleshooting, repairs and servicing as well as the ability to investigate any vessel/aircraft accidents. Initiatives to help design, develop and test as well as help resolve issues throughout any one of these stages are imperative - including modifying designs to improve safety features, minimize fuel consumption and reducing the carbon footprint.

Getting along well with others is crucial in aerospace engineering. You are part of a team that is responsible for sending millions of dollars' worth of equipment, technology and human lives into the air and space; you must work well in tandem with others to make this happen – anything from test f ight programs to measure take off distances, stall speeds, rate of climb, maneuverability and landing capacities to measuring and improving these aspects as well as performance, components and systems. Finally, observation and data analysis round out the process; observation - considering and reporting changes in atmospheric pressure, temperature, structural loads and how it affects air vehicles, and data analysis - the collecting and interpreting of data and inferring and publishing the results in technical report form.

To break these down further, the elements of aerospace engineering overall are numerous and varied. Each area or specialty adds to the significant functional f uidity of aerospace engineering as a whole. According to Wikipedia, some key elements of aerospace engineering (most of which relate to theoretical physics) are:

Fluid mechanics: the study of f uid f ow around objects. Specifically, aerodynamics concerning the f ow of air over bodies such as wings or through objects such as wind tunnels

Astrodynamics: the study of orbital mechanics including prediction of orbital elements when given a select few variables. While few schools in the United States teach this at the undergraduate level, several have graduate programs covering this topic (usually in conjunction with the Physics department of said college or university).

Statics and Dynamics (engineering mechanics): the study of movement, forces, moments in mechanical systems.

Mathematics: in particular, calculus, differential equations and linear algebra.

Electrotechnology: the study of electronics within engineering.

Propulsion: the energy to move a vehicle through the air (or in outer space) is provided by internal combustion engines, jet engines and turbomachinery, or rockets (i.e. propeller and spacecraft propulsion). A more recent addition to this module is electric propulsion and ion propulsion.

Control Engineering: the study of mathematical modeling of the dynamic behavior of systems and designing them, usually using feedback signals, so that their dynamic behavior is desirable (stable, without large excursions, with minimum error). This applies to the dynamic behavior of aircraft, spacecraft, propulsion systems, and subsystems that exist on aerospace vehicles.

Aircraft structures: design of the physical configuration of the craft to withstand the forces encountered during f ight. Aerospace engineering aims to keep structures lightweight and low-cost, while maintaining structural integrity.

Materials science: related to structures, aerospace engineering also studies the materials of which the aerospace structures are to be built. New materials with very specific properties are invented, or existing ones are modified to improve their performance.

Solid Mechanics: Closely related to material science is solid mechanics

Software Engineers

which deals with stress and strain analysis of the components of the vehicle. Nowadays there are several Finite Element programs such as MSC Patran/Nastran which aid engineers in the analytical process.

Aeroelasticity: the interaction of aerodynamic forces and structural f exibility, potentially causing f utter, divergence, etc.

Avionics: the design and programming of computer systems on board an aircraft or spacecraft and the simulation of systems.

Software: the specification, design, development, test, and implementation of computer software for aerospace applications, including f ight software, ground control software, test & evaluation software, etc.

Risk and Reliability: the study of risk and reliability assessment techniques and the mathematics involved in the quantitative methods.

Noise Control: the study of the mechanics of sound transfer.

Aeroacoustics: the study of noise generation via either turbulent f uid motion or aerodynamic forces interacting with surfaces.

Flight tests: designing and executing f ight test programs to gather and analyze performance and handling qualities data to determine if an aircraft meets its design and performance goals and certification requirements.

Radar Cross-Section: the study of vehicle signature apparent to radar remote sensing.

Additionally, aerospace engineering integrates all the components that form an aerospace vehicle – power sources, bearings, communications, thermal control – as well as design, temperature, pressure, radiation, velocity and lifetime span.

Now that the logistics of aerospace engineering have been clarified, what does this mean to young students such as yourself who are considering declaring an aerospace engineering major?

Meghan McCabe, a high school junior in Wilmette, IL., is considering pursuing her studies in engineering - either aerospace, biomedical or electrical as of now. Aside from keeping her GPA at a 3.7 or above (on a four-point scale), aiming for between 30-36 on her ACT and partaking in challenging, relevant AP and honors courses, she's engaged in a slew of extra-curricular activities that make her desirable to schools of her choice, among them, MIT.

"My trouble is that I am enthralled with every aspect of science," she proclaims excitedly. "Aerospace engineering is crucial to our military and space exploration. I originally declared interest in aerospace engineering because of my profound love for space and its natural beauty. My experience launching weather balloons to the edge of our atmosphere, programming cameras and robots, and even traveling to NASA all factored in to my interest in aerospace. However," she notes, "to work with NASA doesn't require an engineering degree. Electrical engineers, for example, are crucial to any area of engineering. There are various ways to service the scientific community within NASA as there is a plethora of medical advancements made by research on the International Space Station, for which biomedical engineers are needed."

As for how she feels about the fact that less than 20% of aerospace engineers are women, she says, that although the statistic is rather low, it's not only a low statistic for aerospace. "While researching colleges, I am lucky to find a percentage between 20% - 30% of women enrolled in engineering courses. It is a problem for women in all STEM fields. However, I cannot think of a better way to change the statistic than going into engineering. One should consider the statistics, but being afraid of them won't change the outcome."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THE WORKFORCE

OVER THE YEARS I HAVE SEEN AN INCREASE IN WOMEN PURSUING CAREERS AND DEGREES IN ENGINEERING; DIVERSITY WITHIN KEY INDUSTRIES BRING MORE CREATIVITY, INNOVATION, AND BETTER FINANCIAL RESULTS

WOMEN IN ENGINEERING

CATHY DEMETROPOULOS

MANY DON'T KNOW THAT SOME OF THE WORLD'S BIGGEST ENGINEERING CONTRIBUTIONS THAT HAVE MADE A SIGNIFICANT IMPACT ON OUR DAILY LIVES WERE MADE BY WOMEN, WAY BEFORE IT WAS SOCIALLY ACCEPTED FOR WOMEN TO WORK IN THESE FIELDS.

EMILY ROEBLING
FIRST WOMAN FIELD ENGINEER AND TECHNICAL LEADER OF THE BROOKLYN BRIDGE

STEPHANIE LOUISE KWOLEK
DISCOVERY OF LIQUID CRYSTALINE POLYMERS LEADING TO CREATION OF KEVLAR

MARTHA J. COSTON
DEVELOPER OF FLARES

EDITH CLARKE
PIONEER IN ELECTRICAL ENGINEERING CONCEPTS FOR DAM BUILDING.

MARY ANDERSON
INVENTOR OF THE WINDSHIELD WIPER

ADA LOVELACE
THE FIRST GREAT TECH AND COMPUTING VISIONARY

WOMEN IN ENGINEERING

Some of the most well-known women engineers you probably haven't heard of are Emily Roebling, first woman field engineer and technical leader of the Brooklyn Bridge; Stephanie Louise Kwolek, whose discovery of liquid crystalline polymers led to the creation of Kevlar (used in bulletproof vests); Martha J. Coston, developed f ares; Edith Clarke, a pioneer in electrical engineering concepts for dam building; Mary Anderson, inventor of the windshield wiper; Ada Lovelace, considered the first great tech and computing visionary, pioneered computer programming language and helped to construct what was considered the first computing machine (the Babbage Analytical Engine); physical chemist Dr. Rosalind Franklin's study in X-ray crystallography led to the discovery of the double-helix shape of DNA; and Tabitha Babbit, inventor of the first circular saw.

"I was one of only five women in my graduating class for Mechanical Engineering at the University of Rhode Island," recalls 24-year engineering veteran Christine Voelker. "Over the years I have seen an increase in women pursuing careers and degrees in engineering, but as a whole, this percentage is still very low. More needs to be done in our high schools to increase awareness and promote STEM (Science, Technology, Engineering, Math) fields of study to educate and encourage young women to pursue these technical fields."

Assistant Professor Negar Elhami-Khorasani who teaches in the Department of Civil, Structural and Environmental Engineering at the University of Buffalo feels the same way. "In the U.S., only about 20% of engineering students are women," she notes. "Although it's been increasing over the past two decades, we still need to improve and encourage women enrollment in STEM. Those of us in the field should encourage, mentor and support further involvement of women students and underrepresented groups in engineering."

Structural engineer Kelley Severns, PE is the National Bridge Research Lead in the Complex Bridge Division of WSP|Parsons Brinckerhoff. She minces no words when it comes to observing the number of women in engineering. "NO," she says strongly. "There are not enough women [in engineering]. I do see an increase in women as students and grad students in engineering however I often see the numbers decline later in careers. Often, family life takes on a larger role for women later in life and many women do not remain in the industry, especially after they've had children. However, it's been my experience that you can do both." She explains, "Workplaces are much more f exible now and allow f ex time, part time, work from home, in-office childcare and contract options in order to ensure a better work-life balance. Insist on these programs and if your employer doesn't have them or won't develop them, don't be afraid to go somewhere that does." She goes on to demonstrate the opportunities that await women in engineering fields. "I personally have NOT experienced a glass ceiling anywhere I have worked, and in

POSTMODERN ARCHITECTURE

The lack of formailty and variety of modern architecture brought about a style or reaction against the plainness known as postmodern architecture. Various engineers are what make architecture what it is. Diversity in key industries such as architecture allows room for creativity, therefore encouraging more women into the field can allow this room for change.

fact, have been encouraged to take leadership roles."

Severns goes on to say that early involvement by women in engineering with young girls is key to increasing the interest and commitment for women in engineering. "I often hear young women say they 'aren't good in math' or could never be an engineer or scientist. "We need to go out and get involved in elementary school career days and science clubs and talk to kids about engineering to pique their interest, or volunteer to work with young girls' programs in STEM areas. We have to work with our young girls early on to show them that girls CAN do math! Girls make choices about math at a young age – by 5th grade – so showing them that women DO work as engineers and scientists can make an impressionable, long-lasting impact."

In fact, STEM and STEAM (incorporating art)-based classes are being introduced to children younger and younger these days - in some cases, even in preschools on very rudimentary yet still effective levels, making it part of standard childhood curriculums. Interest in engineering must start early – and there are several initiatives by schools, companies and organizations to draw young girls, in particular, to STEM/STEAM. Here's a sampling:

For example, in December 2016, INROADS, Inc., a non-profit focused on development and career preparation for talented, underserved youth, received a $100,000 grant from The Coca-Cola Foundation to support College Links Atlanta: Advancing Female High School Students in STEM/STEAM. Developed in Chicago in 1976, College Links exposes talented, diverse high school students to careers in science, technology, engineering and math (STEM) - and STEAM, which adds arts to the STEM subjects – with year-round educational instruction and corporate visits. "Fewer than 1 in 10 employed scientists and engineers are women," said INROADS President and CEO, Forest T. Harper. "With The Coca-Cola Foundation's support, College Links-Atlanta will focus the program's proven ability to improve high school graduation, college enrollment and completion, and eventual career placement, on exposing girls in grades 9-12 to STEM/STEAM careers."

Another example is ESC (Embedded Systems Conference) Silicon Valley, co-located with BIOMEDevice San Jose, who jointly announced in November 2016 its first ever Women in Engineering breakfast discussion panel and networking session. The session will explore any current opportunities offered to women in engineering, and even discuss why there is such a low representation of women in the industry, bolstered by a panel of women engineers taking the field by storm. "Diversity within key industries brings more creativity, innovation, and better financial results. We need a larger and more diverse group of professional engineers in the United States, yet half the population is not approaching the field," says Suzanne Deffree, Content Director for ESC and moderator of the Women in Engineering panel.

The Center for Advancing Women in Technology (CAWIT) launched the first of its kind initiative late last year also, in an effort to close the troubling gap between U.S. college men and women who graduate with computing or IT degrees. As a result, the Technology Pathways Initiative (TPI) was created to increase participation of college women in computer science. According to CAWIT Founder and President, Dr. Belle W. Wei, "Women are drastically underrepresented in the nation's technology talent pool even though they now make up more than half of all college graduates. The Technology Pathways Initiative is a catalyst for systemic change, from campus to career, to educate more women innovators for the Digital Age." Dr. Wei is Carolyn Guidry Chair in Engineering Education and Innovating Learning, and former Dean of the College of Engineering at San José State University. TPI is backed by the White House as part of the CSforAll initiative. Most notably, women account for 60% of college biology majors and 43% of college mathematics majors, according to the National Science Foundation. New interdisciplinary computing education degree programs will prepare them to pursue careers in emerging areas such a bioinformatics and big data analytics.

Anna Culcasi, a civil engineer specializing in water resources, puts it very straightforwardly: "Women make up half the population so women should provide half of the engineering solutions to our infrastructure, energy, and other engineering problems. Women are as innovative as men, so to discourage interested girls from math, science and engineering is to lose half of our nation's engineering talent pool." Culcasi believes that girls are still being discouraged from building and problem solving at a young age. "Many of those toys are designed for boys. Girls tend to respond differently in classes that are seen for boys so teaching techniques could be adapted to accommodate that. Instead of science alone, a class like applied science could be added to curriculums to spark the interest of those that enjoy problem solving. We need to work on all of this until a rebellious streak isn't needed for a girl to feel that engineering is where she belongs. Until women make up 50% of engineers at all levels, there will not be enough women in engineering. I am seeing an increase, so the gap is closing yet there is still much to be done to encourage both genders to pursue engineering as a career."

> **IBM, a prominent partner of NASA and featured prominently in "Hidden Figures" is taking leadership roles in developing STEM outreach education programs, continuing its commitment to diversifying the technology workforce.**

"Hidden Figures", the Oscar nominated film and inspirational true story is pegged to inspire an emerging STEM generation. Nationwide screenings were held for young girls (and boys) for the feature film, the true story of how three African American women engineers helped launch the first rocket into space at NASA. Using this film as a platform, many companies were inspired to provide initiatives to launch STEM related programs for young women all over the country. One of the biggest, was a scholarship contest sponsored by PepsiCo and 21st Century Fox. More than 7,000 girls and women applied and the winners were selected based on their passion for the sciences, innovative thinking and vision for improving the world through STEM. Each of the two winners – one in the professional realm and one high school student – each received $50,000 to put toward education or research, and a trip to Kennedy Space Center in Orland, FL.

IBM, a prominent partner of NASA and featured prominently in "Hidden Figures" is taking leadership roles in developing STEM outreach education programs, continuing its commitment to diversifying the technology workforce. On the coattails of the feature film, IBM partnered with The New York Times to launch a free app called "Outthink Hidden", which combines the true stories of the film's main characters with digitally interactive content to create a nationwide "hunt" or game about STEM figures, historical leaders, STEM pioneers and places and areas of research across the country. IBM views this as an important yet fun and interesting prototype to engage young tech savvy students of all ages in promoting interest in STEM exploration via education, careers and mentorship opportunities.

Overall, initiatives to engage young girls in STEM and STEAM curriculums are emerging more so now than ever before. Thanks to school based programs and initiatives, large corporate involvement willing to subsidize interest in engineering based studies through scholarships, internships and mentoring programs, and yes, even Hollywood, women will start closing the gender gap that lies within engineering industries, hopefully, more than we've ever seen in the past.

TOP TIPS FOR YOUNG STRUCTURAL ENGINEERS

HOW BUDDING STRUCTURAL ENGINEERS CAN SUCCEED IN THE INDUSTRY

In arguably the greatest achievement of the twentieth century, the average life expectancy has almost doubled since 1900, when people would seldom pass the age of 50. However, we now have an aging population, which is reshaping infrastructure and increasing demand from younger generations of structural engineers. Here, Sam Carigliano, CEO of cloud based structural engineering software provider SkyCiv, shares his top three tips for budding structural engineers.

According to a report from the National Institute of Aging in the US there has been a significant life expectancy increase that averages out at approximately three additional months of life in newborns with every passing year. This means that that those born in 2017 will, on average, live one year longer than those born in 2013.

With many experienced structural engineers nearing retirement, young engineers are beginning to take on more responsibility in the workplace. With little experience, they may feel overwhelmed by the pressure and high standards expected in the profession.

Fortunately, there are three key steps that young structural engineers can take at the start of their careers to maximize their personal effectiveness and increase their prospects.

Be social and network

Although networking has been a valuable tool for many years, younger engineers are now armed with social media platforms such as LinkedIn, allowing them to network more effectively than previous generations.

Budding structural engineers should attend events, whether they are general ones such as steel structural engineering shows or niche ones such as oil and gas and event rigging shows.

Engineers should take a digital copy of their resume with them to send across to potential employers and be prepared to connect on LinkedIn. An effective way of managing this is to keep it attached in a draft e-mail or saved on a cloud drive.

If you haven't already, create a LinkedIn profile, write a short introduction, post engaging updates and grow your professional network.

Brush up on your software

Structural engineering software is used to ensure designs are practical, safe and compliant with the relevant regulations, as well as to safely analyze and virtually test the load bearing capacity of structures. Yet the software used in each structural engineering sector can vary.

Young structural engineers should ensure they are familiar with a variety of general and niche software packages. The problem is that, because many traditional software programs require expensive licenses and costly hardware, they've historically been inaccessible to students and those new to the industry.

Fortunately, recent developments in cloud computing mean that there is software that can be accessed on a cheaper subscription model, using nothing but a web browser on a variety of devices.

SkyCiv's structural engineering software, for example, is cloud based so that it can be used on any system with an internet connection, whether it is a Windows PC, Linux system or a Mac. SkyCiv uses a monthly subscription payment model that provides the same standard of structural analysis and testing as traditional software, with frequent free regulatory updates.

Find your passion

Finding an industry niche that sparks your interest is one of the most important things a young structural engineer can do. Use your time at University to experiment with different projects and hobbies in a variety of sectors before choosing a sector that appeals to you most.

Hobby projects can also be really fruitful. For example, SkyCiv began as a hobby project and now, two years later, has been used on more than two million structural engineering projects around the world. Passion is a powerful tool for success.

While longer life expectancies mean that the average age of retirement is increasing and younger generations can work longer, the first step onto the career ladder is often the most difficult. Whether it's as part of an infrastructure company or as a freelance project engineer, structural engineers that consider these three points can take that first step easier.

If you want to ensure you keep up to date with press material, opinion focussed blog content and case studies from SkyCiv, you can read more here https://skyciv.com/blog/.

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COVER STORY

NEW YORK CONTRACTOR COLD SPRING CONSTRUCTION ERECTS STRUCTURAL STEEL FOR A NEW HIGHWAY BRIDGE.

WANTED: BRIDGE ENGINEERS

Years ago, before biomedical or aerospace engineering were even thought of, there were only two kinds of engineering. You were either a military engineer or a civil engineer. While armies were away fighting, civil engineers addressed the needs of the rest of society. Gradually, the skills needed to provide clean water, sanitation, transportation, and safe structures became specialized. Today, there is a strong demand for civil engineers to provide and maintain a wide variety of infrastructure systems that we have come to depend on. American Society of Civil Engineers (ASCE) estimates that $3.7 Trillion needs to be spent on America's infrastructure. The role of a bridge engineer in the coming infrastructure boom is unique because these engineers can shape the character of a community with signature bridges. The Brooklyn Bridge and the Golden Gate Bridge are classic examples of the vision expressed by famous bridge builders, but bridge engineers do much more than design.

"BRIDGING THE GAP AFRICA" RAISES A TOWER TO SPAN A DANGEROUS RIVER CROSSING. BRIDGES LIKE THIS REDUCE THE NUMBER OF DROWNINGS AND ALLOW FAMILIES IN KENYA TO ACCESS HEALTH CARE AND GET AN EDUCATION.

How many bridges and drainage structures did you cross today? Most people do not even know; it's taken for granted that we can get from here to there without getting our feet wet. Non-profit organizations like Bridging the Gap Africa exist to build footbridges in places where that assumption is not valid. When students at University at Buffalo (UB) found out about

DR. OKUMUS (RIGHT) SHOWS OFF HER BRIDGE TESTING APPARATUS TO A PROFESSIONAL COLLEAGUE.

this work, they contacted the organization's founder Harmon Parker to see how they could help. Students have since designed bridges, tackled construction problems, developed procedures to ensure quality, and even raised money to buy bridge materials.

In the U.S., we rely heavily on motorized vehicles. Over 600,000 highway bridges have been built to provide the freedom of movement that we have come to expect. That's an impressive highway system, but it also comes with responsibilities. The "baby boomers" who built many of these bridges are retiring faster than they can be replaced so there is an opportunity for young people who enjoy a challenge to assume stewardship of this vast network.

What are the challenges? Number 1 is money. Funding for infrastructure was a hot topic during the presidential campaign. Because bridges (and tunnels) are a high value part of the surface transportation system, engineers will be a vital part of the process going forward in improving our roads and bridges. Good asset management practices will allow them to know and communicate to others how much money is needed to move people and goods safely, reliably and efficiently.

Another challenge is the age of our highway system. The average age of a bridge is close to 42 years, yet most bridges were only designed for 50. This probably explains why ASCE gave U.S. a grade of C+ on its bridges. This is a little better than mediocre, not much of a claim for a country that prides itself in accumulating gold medals at the Olympic Games. Some new bridges can replace the old ones, but because there are so many, we will have to keep using many aging bridges as long as we can. This will require regular inspections and careful investigation of issues that are discovered. If a bridge engineer determines that a structure is unsafe; (s)he has a professional responsibility to close it. In New York State alone, it costs over $75 million annually to inspect state and

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Institute of Bridge Engineering
University at Buffalo

COVER STORY
continued

WANTED: BRIDGE ENGINEERS

AT UNIVERSITY OF BUFFALO you will interact with professional engineers while doing real engineering projects that give you credit toward your 30 credit M.S. degree. Some other courses can be done online buffalo.edu/enginet. Find out how to become a bridge specialist at buffalo.edu/bridge.

locally owned bridges.

Thirdly, research performed in structural, material and geotechnology laboratories contributes to ever improving design standards. This is good and necessary for advancing the performance of bridges. What this does though, is point out some possible deficiencies in the design of older structures. Take seismic design criteria for example. Strong earthquakes have not occurred frequently in the U.S. but when they strike, a bridge can be destroyed in just a few minutes. After a series of damaging earthquakes, the National Science Foundation provided funding and in 1986, the first National Center for Earthquake Engineering Research (NCEER) was established at University at Buffalo (UB). UB's earthquake center (now named MCEER) has conducted research on bridges that is valued at over $36 million. UB faculty have been instrumental in the development of new technology and design procedures that make today's bridges safer than ever. Knowledge from this research

is reflected in current bridge design specifications unfortunately it was not available when the majority of the nation's bridges were built. This means that there are a lot of older bridges, including some landmark heritage structures that should be analyzed and possibly retrofitted to ensure that they are safe.

If the above challenges are not enough, we can talk about climate change. Recent powerful storms, such as Superstorm Sandy and Hurricane Katrina, have destroyed many structures, new as well as old. In the aftermath of extreme events like these, the importance of redundancy and resiliency becomes apparent. Road infrastructure is essential for accessing stricken areas to provide rescue, relief and reconstruction.

A true leader wants to share insights that they have accumulated over their career. Some of the most renowned bridge engineers in the country have guided the formation of the Institute of Bridge Engineering at UB and contribute to it as guest lecturers and curriculum advisors. These engineers recognize an impending shortage of qualified engineers who will be needed to keep the traveling public safe and safeguard an important part of the country's economy, its bridges. To address this concern, UB now offers a Master of Science degree program with a focus on bridge engineering. In as little as 18 months, one can learn to design a steel and prestressed concrete bridge, to assess safety and reliability in a systematic way, and how bridge management and load ratings are done.

UB puts an emphasis on emerging technologies such as strategies to install bridges over a weekend to minimize disruption to traffic. It also teaches sustainability during all phases of an asset life cycle: planning, design, construction, operation, preservation and eventually decommissioning. The objective of the M.S. program is to produce students that are competent enough to step into a responsible job and become productive to their employer on day one. Of course, this background is also valuable to students who choose to use their knowledge in pursuit a higher degree and eventual research.

In summary, what makes bridge engineering a good career choice?

- There is a lot of satisfaction knowing that you are an essential part of keeping other people safe. It takes special skills that not everyone has.
- Challenges tend to make one's job more interesting.
- Experienced engineers are willing to mentor you to pass on information that is not found in books.
- What you do really matters. You can help shape how infrastructure complements the natural environment, with consideration of future generations.
- You can help build bridges in low income countries.
- Researchers sometimes have to build big structures and break them in the lab to validate their theoretical models. Dr. Okumus tells me that this is a fun part of her job!

At UB, you will interact with professional engineers while doing real engineering projects that give you credit toward your 30 credit M.S. degree. Some other courses can be done online buffalo.edu/enginet. Find out how to become a bridge specialist at buffalo.edu/bridge

CONCEPTS

BY: CATHY DEMETROPOULOS

ENGINEERING'S IMPACT ON THE WORLD

Health and Medicine

There is no doubt that engineering marvels have positively affected and changed the way we live today. How have they changed society and the world and what can we expect going forward?

Practically everything we use in our daily lives has been touched by an engineer. It's hard to say if any one thing or invention is more important than another – they are all equally important in some way.

Engineering, as a whole, encompasses dozens of fields that can cross over into several different disciplines – from medicine to computers – to solve a plethora of challenges. The necessity for engineering drives the evolution of these fields and as such, has reached


Civil Engineering

into every corner of the way society functions. Engineering is one of the most impactful and fulfilling career choices you can make in that some aspect of it touches everything we use in the world today.

It is often said that engineers create something that hasn't existed before or improve on what's already been made. The contributions of engineers throughout history have made possible what is today and have helped in overcoming some of modern life's greatest challenges. Thanks to advancements in technology, their reach continues to grow today, bettering our daily lives in ways we once never thought possible. Exploring just how far engineers' work can reach sheds new light on this field. Below are just some examples in some areas of engineering that have impacted society and the world in more efficient and positive ways.


Structural Engineering

Civil Engineering

It's safe to say that civil engineering extends, in part, to all structural and architectural engineering fields, with several sub-fields as specialties. As an example, Anna Culcasi is a civil engineer in Chicago, specializing in water resources. She performs hydrologic and hydraulic modeling as part of floodplain mapping and storm water studies. She also performs bridge hydraulic studies as part of new roadway designs and creates construction plans, specs and estimates for water resources projects such as dam removal and rehabilitation or stream stabilization. "Large communities and societies cannot exist without infrastructure, which is created through civil engineering," says Culcasi. When asked specifically how her job impacts society and the world, she says. "Floodplain mapping and storm water studies allow municipalities and individual citizens to better understand their flood risks and take action to mitigate those risks. Mitigation actions include upgrades to infrastructure to contain flooding, rapid response to close intersections based on heavy rainfall and property buyouts in high hazard areas."

TODAY, THESE POSE A HAZARD FOR HUMAN LIFE AS THEY CREATE A CONDITION CALLED A REVERSE ROLLER, FROM WHICH PEOPLE CANNOT ESCAPE ON THEIR OWN IF CAUGHT IN THE CURRENT.

Another area of expertise she tackles is the removal of low head dams, popular in the 19th century for producing hydro-electric power and diverting water for grain mills, agricultural irrigation and fish hatcheries. Today, these pose a hazard for human life as they create a condition called a reverse roller, from which people cannot escape on their own if caught in the current. In fact, many drowning deaths have occurred due to people wandering nearby low dams. "The removal of these dams eliminates that risk as well as provides a significant benefit to the ecosystem by allowing fish passage and reducing zones of low oxygen."

Environment

Negar Elhami-Khorasani is an assistant professor in the department of civil, structural and environmental engineering at the University of Buffalo. Her main area of research is investigating the performance of the built environment under extreme loading scenarios, in particular, fire, as a primary or secondary event. "My work investigates the behavior and design of individual buildings for fire scenarios considering uncertainties in the event, as well as determining the resilience of a community after an extreme environmental event such as earthquakes, structural fires and environmental wildfires. The main objective of my work is to ensure our cities and communities are able to cope with sudden shocks and maintain or quickly restore their functions and structures." Professor Negar credits innovative developments such as base isolation systems for protecting structures against earthquakes and in turn, saving human lives. She also credits today's interconnected social and economical networks for aiding in evaluating community resilience and developing mitigation policies for extreme events as necessary to minimize economic and human losses. "We transfer such research and the knowledge we've developed in universities to engineers in industry as well as public authorities."

Health and Medicine

Engineers are behind some of the medical field's most innovative products. These have allowed for example, the creation of better and more innovative wheelchairs for the millions of people who rely on them to live their lives; the development of smaller, more powerful hearing aids that can be surgically implanted and work off of direct neural connections within the brain; the design of more realistic functioning limbs for those in need of prosthetics; the creation of technology that allows blind people to "see" through electrical impulses in the brain; the ability to control the debilitating shaking of Parkinson's disease to allow a patient to write their name for the first time. In fact, the innovations in this field have become so advanced thanks to medical and biomedical engineers that in some cases, have rivaled and even exceeded the human body's capabilities themselves.


Software Engineers

Manufacturing & Manufacturing

Christine Voelker is a mechanical engineer and senior product development engineer at ASSA ABLOY, the global leader in door opening solutions. She is involved with new product development and upgrades to existing products, from design to testing and production. Taking a sketched concept and turning it into a prototype is the crux of what she does – yet in between there are multi-faceted layers that involve many steps. It begins with fabricating parts with the specified materials, turning it into a solid design with the use of 3D printers and other software based machinery and then testing it in an engineering lab for performance strength and destructive security.

People and companies who use the products that Voelker helps develop depend on her to keep them and their properties safe, as well as provide easy and safe egress from those closed doors in the event of an emergency. "For example," she says, "during a violent storm, people seek shelter for protection. If the door hardware fails during a storm, precious lives are at stake. If the door hardware has been damaged from the outside, it still needs to be completely functional on the inside. These are the types things we focus on. On a more positive note, the products we engineer also make our lives easier," she continues. "We no longer need to carry actual keys. People can enter a code on a keypad or simply present a cell phone to unlock a door."

Voelker's colleague, Mia Merrel, utilizes both mechanical and electrical engineering to product test door locks. "Product testing is crucial to our clients because we find faults before the products are released to market," she says. "No one wants to see a situation like what's been happening with the Samsung Note 7 exploding and product testing is how we ensure things like that don't happen."

Robotics, Software Engineers, Computer Technology

These fields, in the grand scheme of traditional engineering fields, are more recent and ever-growing, since the invention of the mainstream computer. Robots and robotic systems have been evolving and for the most part, have had a positive effect on society as they help improve the efficiency of industrial and manufacturing processes. They've also had a positive effect on the health and well being of employees in industrial manufacturing since robots are now being used in environments deemed to unhealthy or dangerous – such as with harmful pesticides, fumes and extreme temperatures. They reduce the overall risk of injury to human workers. Computer Technology affects our lives positively by enhancing methods and efficiency of communication across the globe. It facilitates access to information like never before and revolutionized the way business is done. It also promotes learning and the process of building professional relationships through networking. Software engineers are the bloodline for technology today. Their expertise in utilizing computer science, math analysis and algorithm development have created software that enables computers to perform applications.

Structural Engineering

In August of 2007, the I-35W Mississippi Bridge in Minneapolis, MN collapsed during the height of rush hour. The bridge carried an estimated 140,000 vehicles per day. The National Transportation Safety Board cited the main cause of the collapse to be "a design flaw" - a failed gusset plate. Structural engineer Kelley Severns references this collapse as it pertains to her career field and the importance of proper structure and maintenance. "The country finally realized the great need in the U.S. to maintain our infrastructure to keep the traveling public safe," she recalls. "Since that event, the bridge industry has worked hard to make sure that our infrastructure will continue to provide safe access to everyone. Technological advances," she continues, "have been made in the way we inspect bridges (such as using drones to keep workers out of traffic and harms way), material innovations that provide a longer service life of bridges (even 100 or more!) have been studied, and decision making tools have been developed to help financial decision makers optimize the use of limited funds."

Overall, we can say that engineering advancements, coupled with technological advancements, have not only improved our quality of life across the globe but have also made it safer. From faster, more efficient and safer transportation modes by land (cars, trucks), sea (ships, barges, ocean liners) and air (commercial airlines, space exploration) to the environments each utilizes (cleaner air via pollution control, and cleaner oceans and waterways to innovative and safer infrastructure). Engineering has changed the way we communicate (computers, cell phones, software and hardware innovations) and the way we are healed, through medical advancements in bio health and science to prevention. We've gone further into space and dived deeper into our oceans. We are utilizing machines that can do things humans cannot do or in situations where it poses a danger to do so. The list of engineering marvels and the positive impact on society goes too far and wide to list every achievement and its impact - just like how the vast number of engineering disciplines evolve and continue to educate us and make our lives easier, more efficient, healthier and safer.

WHICH ENGINEERING FIELD IS RIGHT FOR YOU?

SO YOU'VE MADE THE DECISION TO STUDY ENGINEERING, OR MAYBE YOU'RE STILL CONTEMPLATING WHAT YOU CAN DO IN ENGINEERING.

BY: CATHY DEMETROPOULOS

Taking into consideration your interests and talents, the time has come to ask yourself, 'Which field of engineering am I interested in? Which one is right for me?' Not only is engineering one of the fastest growing job sectors in the United States, but the number of possible fields to focus on is also rapidly expanding. There are new engineering fields cropping up every year with the advances in technology, but here, we touch on some of the most traditionally popular engineering degrees. Keep in mind that there are sub categories to most of these fields as well. Surely, you'll find at least one area that matches your interests and skills, or pique your interest in something you never knew you had interest in at all!

Aerospace Engineering

This particular field is broken down further into two categories, depending on your interests. Aeronautical engineers learn about the practice and technology required to fly aircraft and other vessels within the Earth's atmosphere such as airplanes and helicopters. They design, for example, propulsion systems, navigation systems and various aircrafts while studying the aerodynamic performance of materials. Astronautical engineers focus on spacecraft and the science and technology required to fly outside the Earth's atmosphere into space such as satellites and rockets.

Agricultural Engineering

Here, you can help design and build equipment that will aid in the more efficient and environmentally safe ways of growing, farming and harvesting crops. The goal is to work to reduce inefficient methods of farming by eliminating farmer/operator fatigue, cut down on time and eventually, increase production.

Architectural Engineering

Since this segment focuses on the safety of buildings, it often goes hand in hand with other engineering disciplines like civil and mechanical (see below). These engineers work closely with architects to ensure that buildings are properly, sustainably and safely constructed.

Biomedical Engineer

If you have an interest in medical science, this field is for you. Your job would be to analyze, design and implement solutions to problems in the medical science industry. You essentially use technology to treat or alleviate biological or medical problems such as create prosthetic legs in various sizes, grow tissues to repair damaged ones inside the body and develop disease treatments that are safe.

Chemical Engineering

Here you use your chemistry, physics and math skills combined with engineering tools to either develop or streamline chemical production to make is safer. This can include developing non-toxic cleaning products and cleaner sources of energy, and refining gasoline and other fuels and treating waste. The other side of chemical engineering takes place in medical research and development labs that allows you to perhaps developing ways to mass produce vaccines or develop a drug for cancer treatment with non-life threatening side effects

Civil Engineering

These are the designers and builders of our infrastructure, not limited to, but including: buildings (see architectural), railroads, highways, tunnels, airports, bridges, dams and waterways. Their jobs run the gamut from planning and designing to inspecting and operating/managing. As you can imagine, the responsibility that comes with this is huge; civil engineers have tremendous job liability to ensure the safety of their designs and construction. Using computer technology and advanced materials they create and build infrastructure to meet the current and future needs of our growing world, as well as reducing the dangers from natural disasters that may occur, such as earthquakes.

Computer Engineering

The most popular platforms used today, such as Google, Amazon, Facebook and other social media, were all made possible due to technology developed by computer engineers. The two main sub-categories in this field are computer hardware engineering and computer software engineering but many more aspects are coming into play now such as cyber security, signal and information processing, communications networks, wireless communications and data analytics to name a few. They apply scientific theory and engineering to design new systems and machines or write programs to solve related problems.

Earth Resources Engineering

This field revolves around finding ways to protect the Earth's resources. You'd be involved with developing ways to efficiently recycle or dispose of used materials and waste, devise ways to improve and oversee drilling and mining operations and even designing mines in general. This field ensures the safety and sustainability of our planet's resources such as fossil fuels, rocks, minerals and water.

Electrical Engineering

Learn to keep up with the latest technological advancements by designing, developing and working with electrical systems and electricity in all its forms – from electrons to large scale magnetic fields. Electrical engineers can design, construct and operate new electrical-based products such as better MRI scanners or advancements in cell phones. They have also been known to specialize in specific areas such as space communications, where they can work on advanced global satellite communications.

Environmental Engineering

The effects the world population is having on the environment have become more apparent as years go by, so the popularity and potential for growth in this field is high. As an environmental engineer, you combine the principles of biology, chemistry and science to study the effects of water, land an air and come up with real world solutions to environmental issues across the globe; this could be projects like designing solutions and strategies to reduce pollution, poor quality in drinking water, cleaning up harmful oil spills in our oceans or chemical reduction and eradication on farmland crops.

Industrial Engineering

Sometimes referred to "productivity people" and "efficiency experts" they work mainly in manufacturing or production plants to assess current processes and systems and streamline them by coming up with more cost-effective and higher efficiency solutions. These days we are seeing industrial engineers venture into other business environments like tech-focused businesses, primarily due to the increased advancements of technology. Examples of what they do, include designing ergonomic office spaces, determine what is best done by people vs. machines, streamline services for global companies and develop customer service methods that really make a difference.

Materials Engineering

Develops materials that combine mechanical, chemical and electrical properties that result in technologically advanced results in materials like metals, plastics and ceramics and even materials that can be used in the medical field. Typically, they do most of their research and development in labs, busy working on things like water or mosquito repellant clothing, bullet-proof fabrics and surfaces, creating artificial yet realistic skin grafts for burn victims, or enhancing the flexibility of snow skis for better handling and less injuries.

Mechanical Engineering

There are many sub-categories within this field, including heating & cooling, thermodynamics, manufacturing and more. Mainly, mechanical engineers design machines and tools that take into account the material, heat and energy transfer and the manufacturing technologies so that they can design all kinds of mechanical items such as machines, tools and engines. They can develop anything from smart cars to smart toys for kids, as well as aid in medical advances such as creating a prosthetic hand that can work like a real one.

Nuclear Engineering

You develop methods and tools and oversee the systems of nuclear energy and radiation. You could be involved in anything from nuclear power production to operating and managing nuclear power stations to proper oversight of nuclear waste disposal. Here you harness the power of nuclear energy and radiation to do things like design nuclear power systems for spacecraft, design fusion reactor systems, and develop uses for radioactive materials.

Robotics Engineering

This is a combination of computer science, electronics, programming, signal processing and systems engineering. In the traditional sense, advancements in robotics engineering have meant developing systems to automate repetitive tasks, especially in production lines, such as vehicle production. Most recently, this field is leading the cutting edge with the introduction of modern, technologically driven items such as drones and driverless cars. Your role in helping to deliver higher levels of safety, consistency, precision, efficiency and reducing human error is what developing robotic advancements will help achieve.

Software Engineering

Since the emergence of computers, this field has boomed and will continue to do so with the advancements of technological platforms constantly being developed. Almost every business is reliant on software engineers to write programming code for their applications such as websites and apps. They are also dependent on open source or proprietary code and applications to run their business and you can help them do anything from develop a more user-friendly blogging software to testing a new video sharing website.

Special Fields & Interdisciplinary Engineering

This field allows more flexibility in that it takes your interests into consideration and applies engineering to them, since some aspect of engineering goes into almost everything these days. Whether they be traditional, nontraditional or interdisciplinary, you can incorporate engineering into industries such as sports, music, law, geography, psychology, business or education. Below are several examples in different interdisciplinary fields where engineering can be applied:

- A forensic engineer can investigate a suspicious explosion at a manufacturing plant
- An oceanographic engineer can design instruments that can map t he ocean floor
- An acoustics engineer can develop a better soundproof design or advanced studio
- A sports engineer can create equipment for training athletes
- A package engineer can create a container that extends the shelf life of a certain food

Structural Engineering

Any structures you can think of, such as houses, buildings, courthouses, theaters, malls, museums and other notable buildings, have had a structural engineer involved in their planning and creation. Working closely with architectural engineers, structural engineers use science and math to design and create structures that are accommodating and safe.

Are you studying or looking into a unique field of engineering not mentioned above? We'd love to hear from you! Please email us at Editor@NewEngineerUSA.com