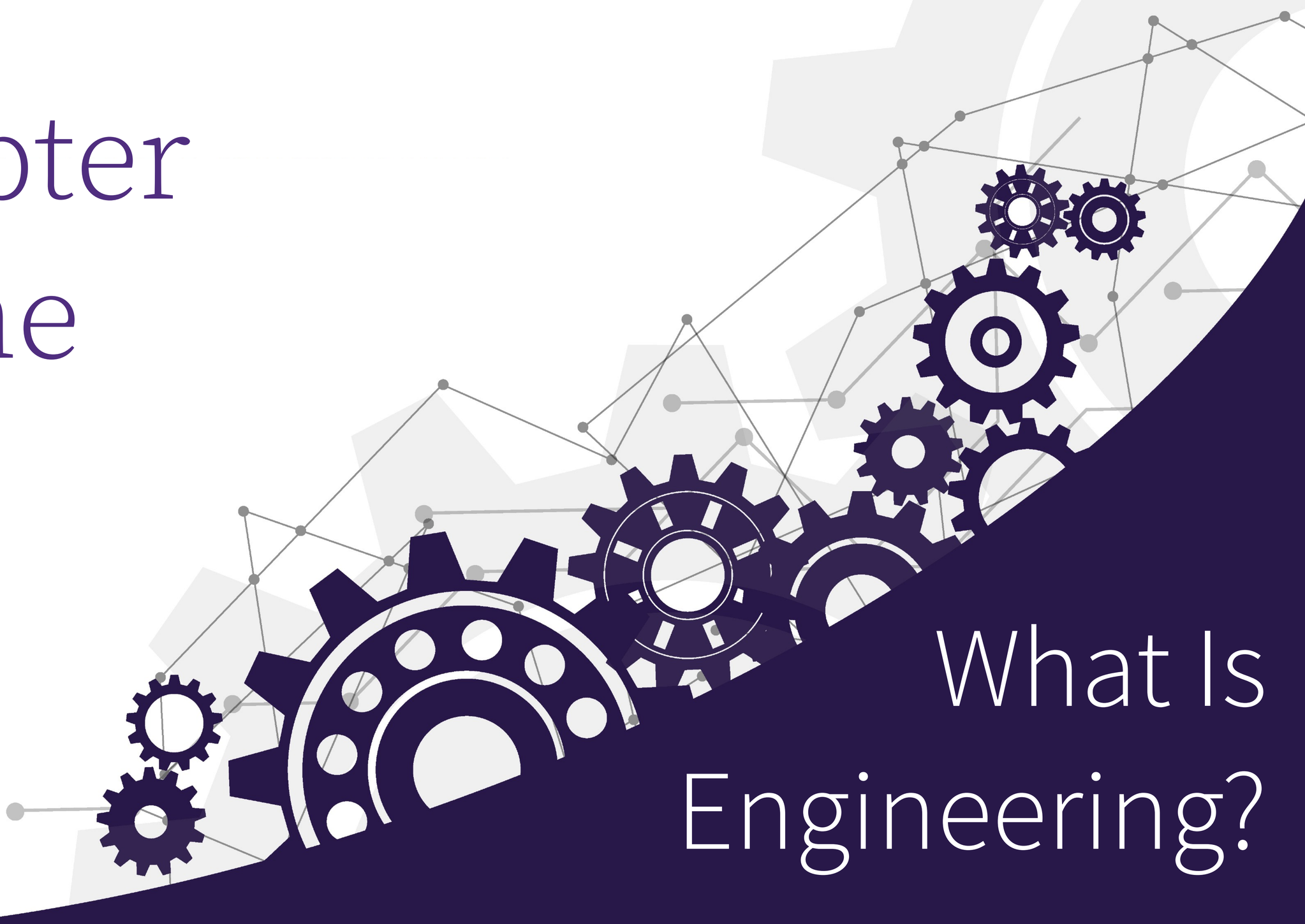
Chapter One



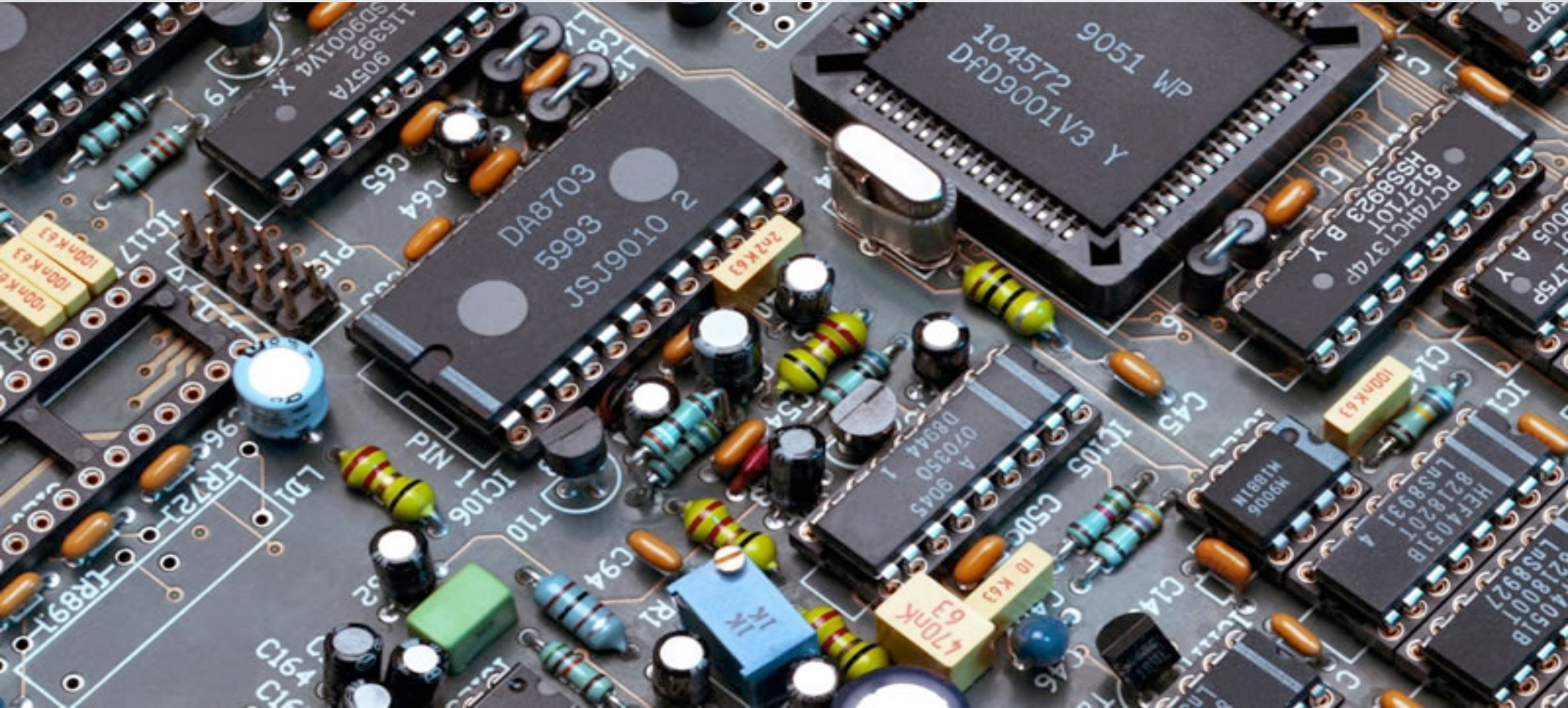
What Is Engineering?

WHAT IS ENGINEERING?
WHAT DO ENGINEERS DO?

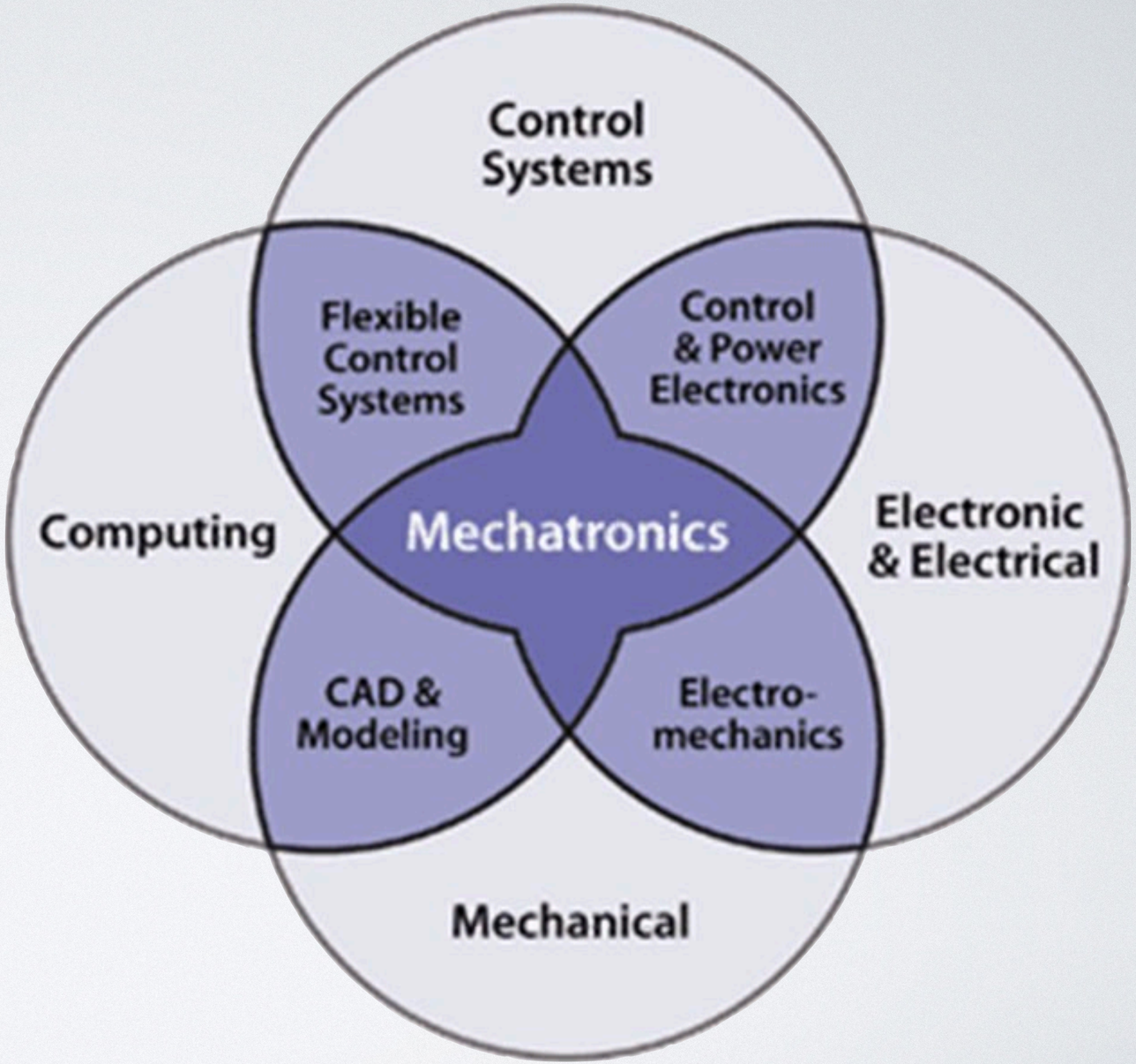
Take a minute and write down 5-7 things you think engineering is or what you think engineers do.

SO, WHAT IS ENGINEERING?

Short answer:
Everything.



ENGINEERING DISCIPLINES

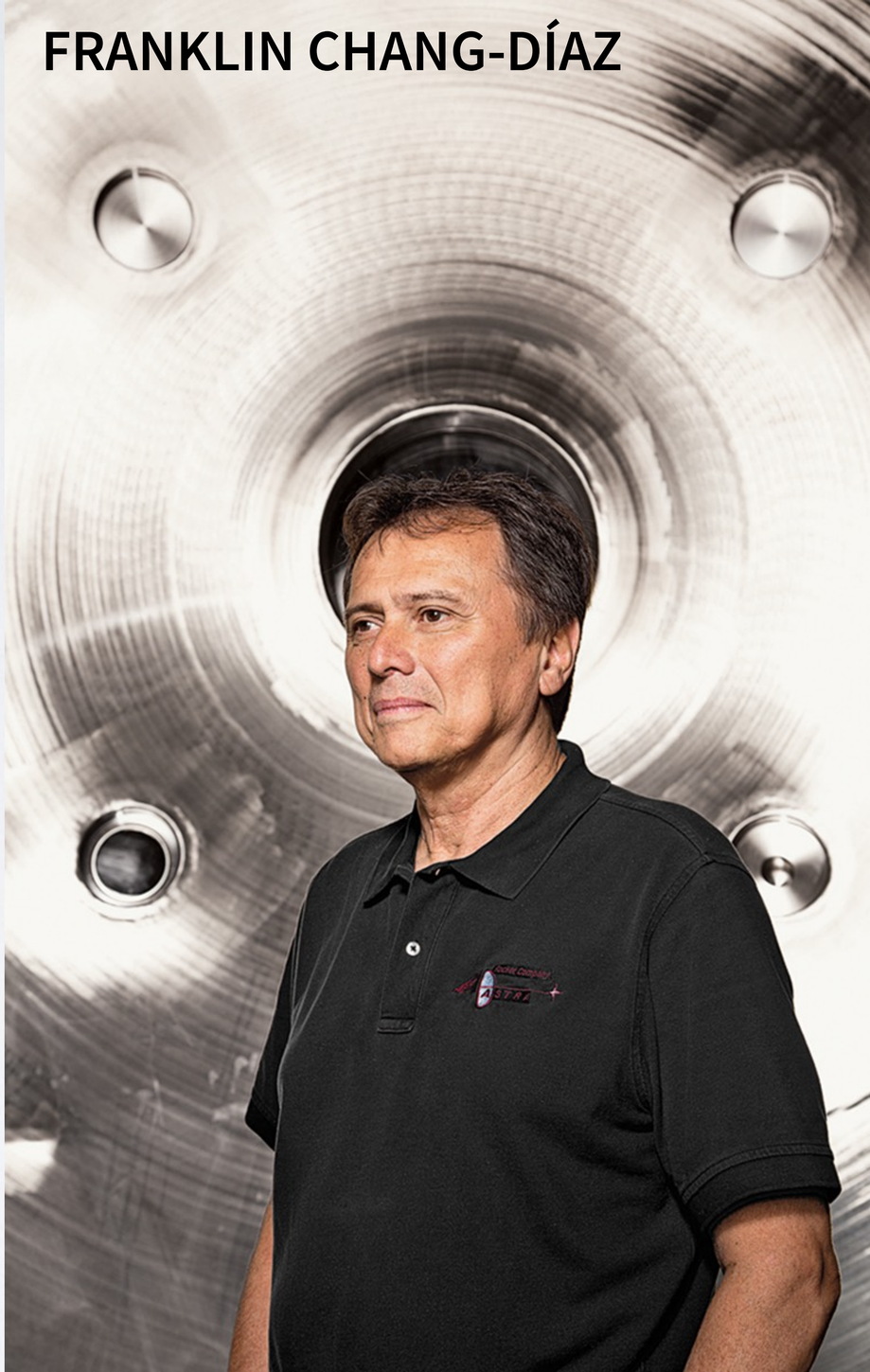


MECHANICAL ENGINEERS

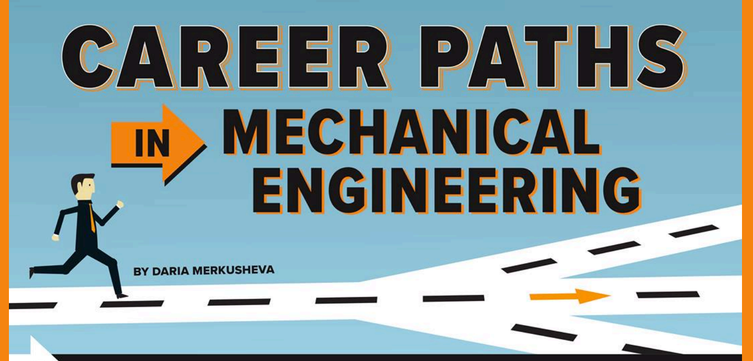
- **Alba Colón**
  BSME, University of Puerto Rico
  Director of Competition Systems, Hendrick Motorsports
  Former NASCAR Sprint Cup Program Manager at General Motors

- **Nathaniel C. Wyeth**
  BSME, University of Pennsylvania
  Invented polyethylene terephthalate (PET), the soda-bottle plastic

- **Franklin R. Chang-Díaz**
  BSME, University of Connecticut
  PhD, Applied Plasma Physics, MIT
  Founder, Ad Astra Rocket Company



CAREER PATHS IN MECHANICAL ENGINEERING



BY DARIA MERKUSHEVA

1 IS MECHANICAL ENGINEERING A GOOD CAREER CHOICE?

Absolutely! Your work can change the world.

- **A secure future:** Job growth **4%** from 2018 to 2028 and even more, depending on the industry.
- **A broad set of expertise:** Technical and mechanical skills, math skills, IT skills and analytical thinking, communication and leadership skills, problem-solving skills, creative thinking.

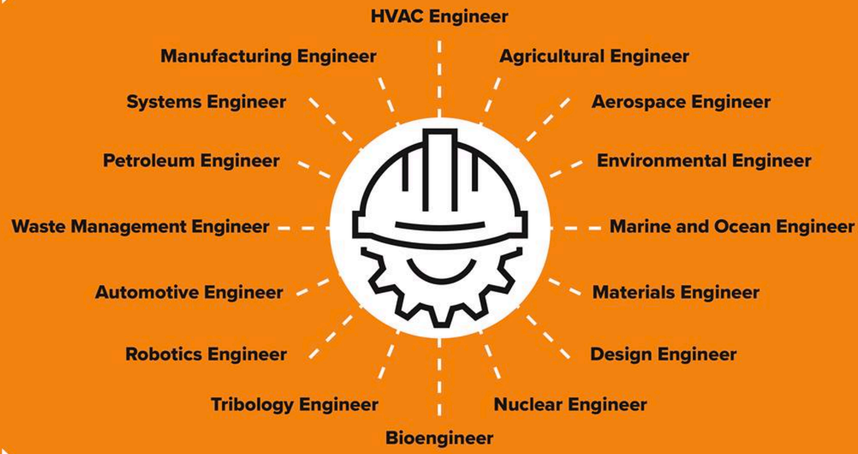
- **A good salary:** Median annual wage was **$87,370** in May 2018.
- **You can work practically in any industry anywhere in the world.**

2 HOW TO START A CAREER IN MECHANICAL ENGINEERING?

Bachelor's Degree → An **Entry-Level Job** in one of the industries employing the biggest number of engineers

INDUSTRIES	SKILLS NEEDED
ENGINEERING SERVICES These are consulting companies with a project-based work structure.	◆ Project management skills ◆ Communication skills ◆ CAD, simulation, and other software proficiency
MACHINERY MANUFACTURING These are assembly plants and suppliers that work on designing and manufacturing industrial and commercial machinery.	◆ Technical skills including design, testing and analysis, fabrication and machining processes ◆ Additive manufacturing familiarity ◆ CAD, simulation, and other software proficiency
SCIENTIFIC R&D These are private, public, government, or corporate R&D laboratories and facilities.	◆ Creativity ◆ Problem-solving skills ◆ Math skills ◆ Analytical thinking
AEROSPACE MANUFACTURING These are the facilities that design and build engines and other components for the aerospace industry.	◆ Mechanical skills, understanding aerospace technology ◆ CAD and other software proficiency ◆ Technical skills, including machining processes ◆ Communication skills and creativity
FEDERAL GOVERNMENT The U.S. federal government is the country's biggest employer, and these jobs include working for NASA, Department of Defense, or other agencies.	◆ They will vary from job to job

3 WHAT JOBS CAN A MECHANICAL ENGINEER DO?



4 HOW MUCH DO MECHANICAL ENGINEERS GET PAID?

Salaries vary because of many factors, including **work experience, degrees, certifications, location,** and **the industry.** Here are some annual mean wages that mechanical engineers are paid, depending on their industry:

Oil and Gas Extraction	$126,880
Waste Treatment and Disposal	$120,200
Waste Management Services	$109,560
Petroleum and Coal Products Manufacturing	$108,980
Spectator Sports	$107,110
Scientific R&D	$103,720
Aerospace Manufacturing	$103,000
Federal Government	$99,370
Engineering Services	$97,310
Engine, Turbine, and Power Transmission Equipment Manufacturing	$96,890
Transportation Equipment Manufacturing	$86,030
Household Appliance Manufacturing	$84,440
Machinery Manufacturing	$84,240

Source: U.S. Bureau of Labor Statistics

MECHANICAL ENGINEERING
THE MAGAZINE OF ASME

ADAPTABILITY!

MECHANICAL ENGINEERING

Mechanical Engineering, a Global perspective

- Rising costs & increasing margin pressure and consistent thrive to shorten product development time
- Product Localization to cater to local requirements
- Stringent government standards & environmental regulations

Mechanical Engineering
An HCL ERS perspective

- Product customization based on a clear know-how of local standards & regulations
- Developing complex mechanical designs and thereby significantly reducing T2M
- Creating high value solutions using the best processes, latest technologies and in-house capabilities

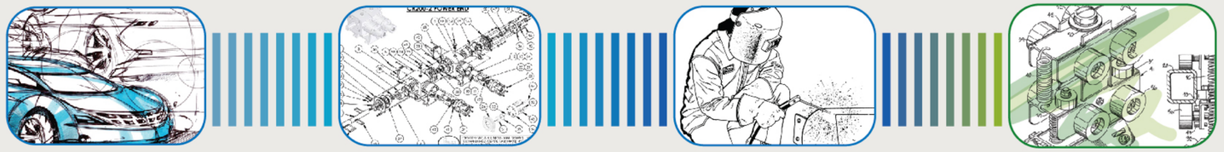
What we do @ HCL ERS

- **$8 Million+** investments in the ecosystem – lab infrastructure, SME & industry consultants
- **$30 Million+** of value creation for customers in the last 3 years
- **$300 Million+** saved for engineering companies through value managed services, with average cost savings of 25-35%
- **50+** Patents filed for customers

All this backed by **15+ YEARS** of powerful legacy and global presence in 30+ countries

MECHANICAL ENGINEERING @ HCL ERS

Concept to Manufacturing — Product Maintenance



Concept | Design | Modelling & Detailing | Analysis | Reliability | ECO | Testing | Manufacturing Support | Obsolescence Management | Design Maintenance

All this resulting in 6 of the Top 20 global R&D spenders partnering with HCL-ERS Mechanical SDU

HOW WE DID IT

For a global Consumer Electronics leader

- **4 Years** partnership across 8 product families and 110+ products
- **95%+** Software quality assurance
- Impacted **23%** of overall company revenue

For a world renowned Medical Devices Manufacturer

- Concept to realization of a Class III medical device
- Created a unique implantable drug delivery system, integrated sensor for drug usage & delivery

Extendend Battery life up to **8 Years**

ENGINEERING AND R&D SERVICES

HCL

Career opportunities to suit any/every possible interest


FLORENTINO PERÉZ


HAL IYENGAR

CIVIL ENGINEERS

- **Florentino Pérez Rodríguez**
  BSCE, Technical University of Madrid
  Chairman and CEO of Grupo ACS
  President of Real Madrid

- **Srinivasa “Hal” Iyengar**
  BSCE, University of Mysore
  MSCE, University of Illinois
  Project Engineer: John Hancock Center, Sears Tower, McCormick Exposition Center, Soldier Field, Millennium Park

- **John A., Washington, and Emily Warren Roebling:** father, son, and wife
  Designed & built Brooklyn Bridge

- **Elsie Eaves**
  BSCE, University of Colorado
  First female member of the American Society of Civil Engineers


EMILY ROEBELING

ROUGH ROAD AHEAD

THE ECONOMIC IMPACT OF AMERICA'S FAILING TRANSPORTATION INFRASTRUCTURE BY 2020

Families have a
LOWER STANDARD OF LIVING.

American families would earn **$700 less** each year.

+

And spend **$360 more** each year.

=

Total impact on each family's budget:
$1,060 per year.

American businesses and workers
PAY A HEAVY PRICE.

America would lose **877,000** jobs.

Another **234,000** jobs exist only if many more workers agree to paycuts.

Between now and 2020 transportation costs
increase $430B.

AMERICA LOSES GROUND
in the global economy.

U.S. exports would drop by **$28 billion**.

+

Exports drop in **79 of 93** different tradable commodities.

=

America's gross domestic product underperforms by
$897B.

FOR AN ADDITIONAL INVESTMENT OF $94B PER YEAR WE CAN:

- + Create millions of jobs
- + Protect another 1.1 million jobs
- + Save nearly 2 billion hours in travel time
- + Save each family $1,060 per year
- + Add $2,600 in GDP for every person in the U.S.

Source: American Society of Civil Engineers

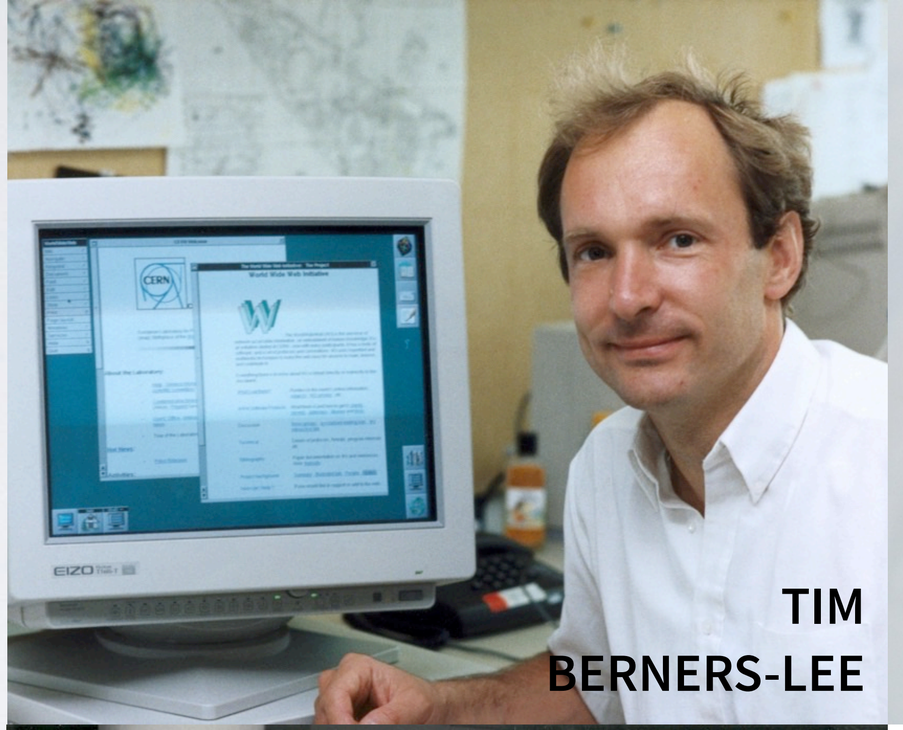
COMPUTER ENGINEERS

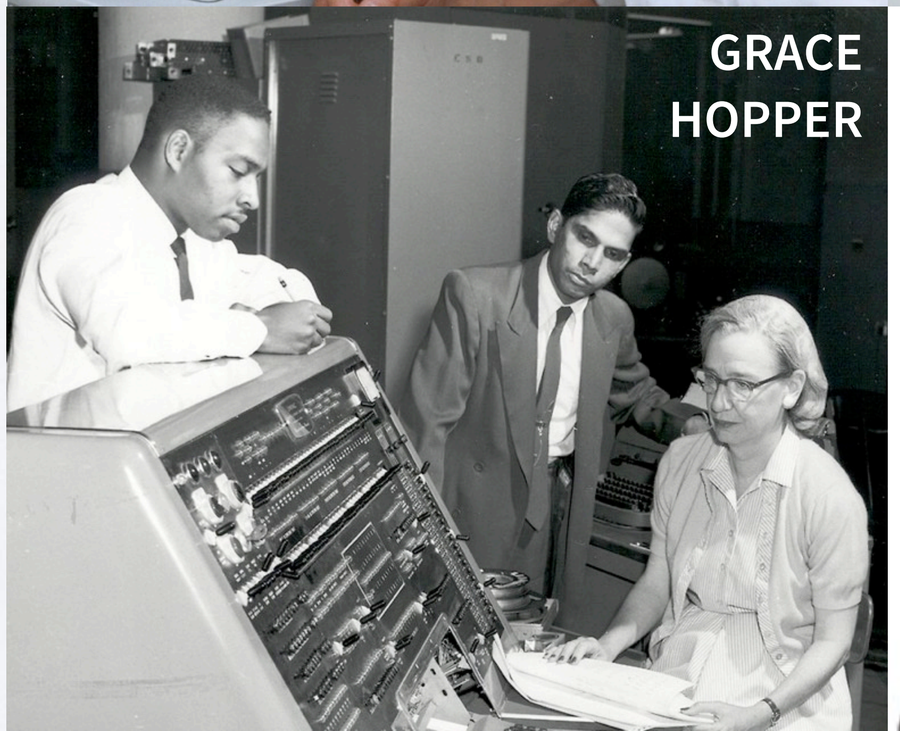
- **Tim Berners-Lee**
  BA Physics, Queen's College, Oxford
  "Invented" the internet: devised/implemented the first information management system for remote communication between HTTP client and server
  Director of W3C

- **Sergey Brin**
  BSCS, University of Maryland
  MSCS, Stanford University
  Co-founder of Google

- **Rear Admiral Grace Hopper, USN**
  BS Physics, Vassar
  MS, PhD Mathematics, Yale University
  Developed first functional compiler for UNIVAC

- **Lynn Conway**
  BSEE, MSEE, Columbia University
  System design pioneer: Literally wrote the book on VLSI





Software Engineer vs Hardware Engineer

Job Title	Software engineer	Hardware engineer
Job Description	Develop, design and test software or construct, maintain computer networks and programs	Research, develop and test hardware or computer equipment
Education	Software Engineering or Computer Science Degree	Electrical & Computer Engineering Degree
Skill Sets	Technology Design, Complex Problem Solving, Critical Thinking, etc.	Troubleshooting, Problem Solving, Systems Evaluation, etc.
Salary	$107,840	$112,760
Number of Jobs	>1,128,000	>87,000

ComputerCareers.org

WHY CONSIDER A CAREER IN CYBERSECURITY?

As cybersecurity threats continue to grow, the demand for qualified candidates increases, but ...

MORE THAN 85% of global IT professionals believe there is a significant shortage of cybersecurity professionals[1]

Information Security Analyst was ranked as the 5th hardest position to fill in **2017**[2]

At the beginning of the 2017 there were roughly

299,335

unfilled positions within the cybersecurity industry[3]

How many cybersecurity professionals will be needed in 2019?

6 MILLION[4]

If job security isn't enough to convince you to work in cybersecurity, the

AVERAGE PAY

for 5 popular industry positions are[5]

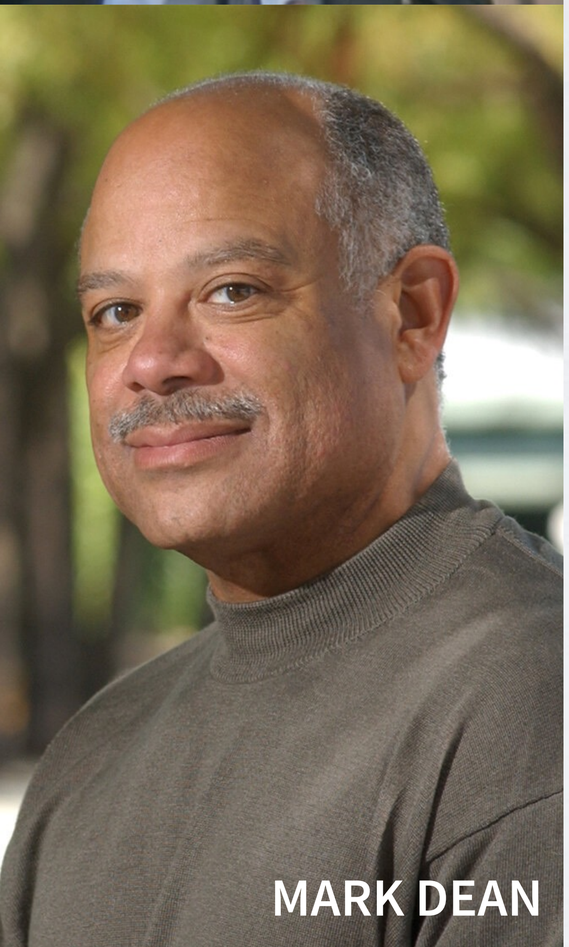
Software Developer **$102,280**

Network Architect **$101,210**

Cybersecurity Analyst **$92,600**

Systems Engineer **$87,220**

Systems Administrator **$79,700**



ELECTRICAL ENGINEERS

- **Harvey Nathanson**
  BSEE, Carnegie-Mellon University
  Patented first MEMS device (holds more than 50 patents)

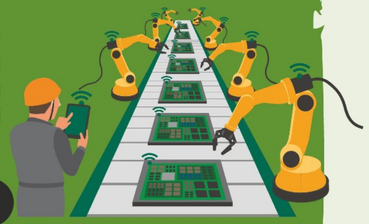
- **Dr. Mark Dean**
  BSEE, University of Tennessee Knoxville
  PhD EE, Stanford University
  First African-American fellow at IBM

- **Dr. Sung-Mo Kang**
  BSEE, Fairleigh Dickinson
  MSEE, SUNY Buffalo
  PhD, UC Berkeley
  Developed world's first 32-bit microprocessor chips

- **José Hernandez**
  BSEE, University of the Pacific
  MSEE, UC Santa Barbara
  Developed the first full-field digital mammography imaging system; Turned down 11 times before finally being selected by NASA for astronaut training

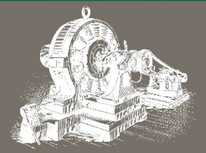
HOW ELECTRICAL ENGINEERING HAS SHAPED THE MODERN WORLD

From light bulbs and television, to cell phones and GPS, modern advances in electrical engineering have illuminated, informed and connected the world.



THE DYNAMO

1831



Electricity became viable for use in the industry when Michael Faraday invented the electric dynamo (a crude electrical generator), which solved the problem of generating a stable electric current and opened the door to many other electric-powered conversion devices.

THE LIGHT BULB

1878

Thomas Edison and British scientist Joseph Swan invented the incandescent filament light bulb in their respective countries in 1879. Edison used his direct-current system (DC) to illuminate the first New York electric street lamps in September 1882.

MOTORS

1887

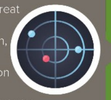
Nikola Tesla is well known for discovering alternating current (AC), and the polyphase distribution system, which is particularly useful for transmitting power to electric AC motors. George Westinghouse, an industrialist and inventor, was so impressed by Tesla's work that they formed a partnership that led to the nationwide use of electricity in America.

TELEVISION

1928

Philo Farnsworth made the first public demonstration of purely electronic television. During the 1930s, several countries began broadcasting, and after World War II, it spread to millions of receivers.

RADAR & RADIOLOCATION



After World War I, the threat of aerial bombing was seen as a major concern and the threat of air attack stimulated work on this technology. Radar was considered a high priority competitive advantage during World War II, and the military poured resources into its development. By the time the United States entered World War II in 1941, the 105-MHz SCR-270 and the 205-MHz SCR-268 were available for use.

La
1930's

COMPUTERS

1941

Konrad Zuse developed the Z3, the world's first programmable computer. The arithmetic performance of these machines allowed engineers to develop completely new technologies and achieve new objectives, such as NASA's Apollo missions.

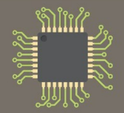
TRANSISTORS

1947

The invention of the transistor in 1947 by William B. Shockley, John Bardeen and Walter Brattain opened the door for more compact devices and led to the development of the integrated circuit in 1959 by Jack Kilby.

MICROPROCESSORS

1968



Marcian Hoff invented the microprocessor at Intel which ignited the development of the personal computer.

SATELLITES

1979

Commercial long distance telephone service was established via communication satellites in Tokyo.

INTERNET PROTOCOL

1981

RFC 791 introduced the Internet Protocol version 4 and **RFC 793** introduced the Transmission Control Protocol (TCP) — thus creating the TCP/IP protocol that much of the Internet relies upon today.

MODERN SATELLITE COMMUNICATIONS

1990s

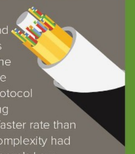
The earliest versions of modern satellites occurred in the 1990s as the pricing for commercial satellite transponder channels continued to drop significantly.
These included:

- Mobile satellite phones
- Satellite radio
- Satellite television
- Satellite Internet access

OPTICAL FIBER

Late 1990's through 2000

There were huge increases in demand for communications bandwidth due to the increased use of the Internet. Internet protocol traffic was increasing exponentially, at a faster rate than integrated circuit complexity had increased under Moore's Law



With the ability to carry 100 times more information than cable with electronic amplifiers, optical fiber became more mainstream during the late 1990's and continues to provide access to billions worldwide.

Wi-Fi

2000

The combination of Wi-Fi and portable Internet access connects us to an unceasing flow of information.

The term Wi-Fi is actually a trademarked name referring to the data-exchange technology based on the IEEE 802.11 standards and 2.4- and 5-GHz bands.

SMART PHONES

Mid-2000s

Smartphones have existed in Japan since 1999 but gained mass adoption globally in the mid-2000s.

SPACE EXPLORATION

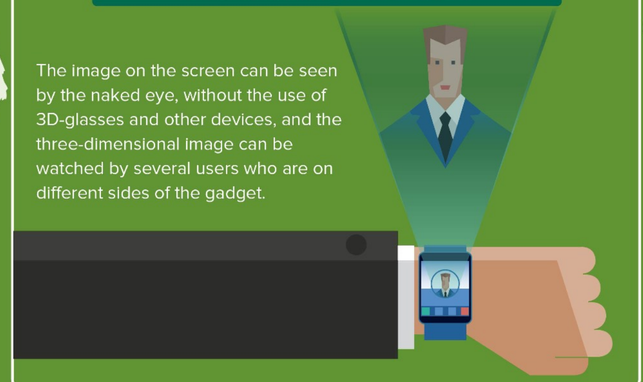
2004/
2012

The Mars Opportunity and Curiosity rovers are a marvel of contemporary engineering, braving the inhospitable Martian environment in their quest to study soil, rocks, atmospheric conditions and microscopic particles.

THE FUTURE OF ELECTRIC ENGINEERING

THE FLEXIBLE SMARTPHONE WITH A HOLOGRAPHIC DISPLAY

The image on the screen can be seen by the naked eye, without the use of 3D-glasses and other devices, and the three-dimensional image can be watched by several users who are on different sides of the gadget.



DRONES

Currently being used for photography, reconnaissance and warfare. This technology is becoming more commonplace both at home and within the military.

A new wall-climbing drone can even approach any type of structure by flying and sticking to the target, changing its pose using a perching mechanism.

THE FUTURE SMARTWATCH

A technology that does not require touching the touch screen or the device itself.

The development, dubbed SkinTrack, consists of a special ring and sensitive receiver in the form of a bracelet, which together can convert tactile contact into signals.

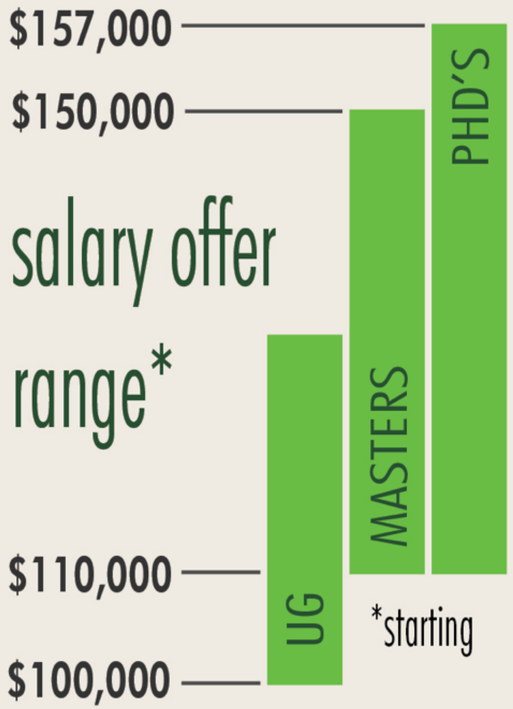
More and more, electrical engineering is reaching into new and exciting fields. Future electrical engineers will need to be ready to collaborate across industries such as wearable technologies, entertainment and sustainable manufacturing.

CS/EE Graduate Salary Survey 2015-2016

conducted by Stanford Computer Forum

with responses from 150 Undergraduates | 175 Masters | 60 Ph.D.s

average **2** internship experiences



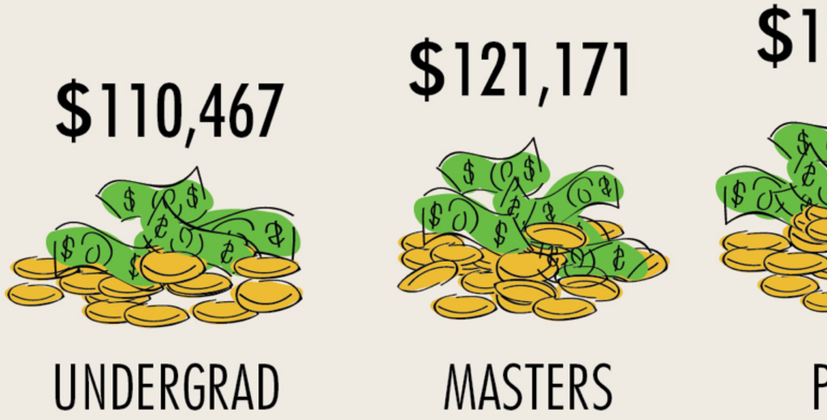
salary offer range*

STOCK options significantly higher for Ph.D.s

offer acceptance factors

- ✓ location
- ✓ company
- ✓ people they work with
- ✓ environment/culture
- ✓ salary/benefits
- ✓ scope of work
- ✓ growth opportunities

average salaries offered



average signing bonus

$15,556 UG

$14,652 MASTERS

$28,533 PH.D.

CHEMICAL ENGINEERS

- **Alicia Boler Davis**
  BSCE, Northwestern University
  MS, Engineering Science, Rensselaer Polytechnic
  Former Executive Vice President of Global Manufacturing, General Motors
  Current CEO of Alto Pharmacy

- **Dr. Robert W. Gore**
  BSCE, University of Delaware
  MSCE, PhD, University of Minnesota
  Invented Gore-Tex technical fabric

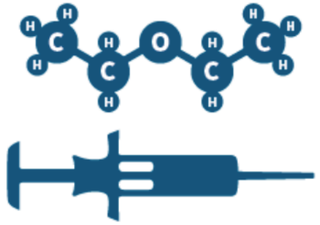
- **Dr. Mario Molina**
  BSCE, National Autonomous University of Mexico
  PhD, University of California, Berkeley
  1995 Nobel Prize in Chemistry for discovery of ozone depletion due to CFCs

- **Sherilyn McCoy**
  BS Chemistry, U Massachusetts Dartmouth
  MSCE, Princeton University
  MBA, Rutgers University
  Holds five US patents, current CEO of Avon Products

WHAT'S CHEMISTRY EVER DONE FOR US?

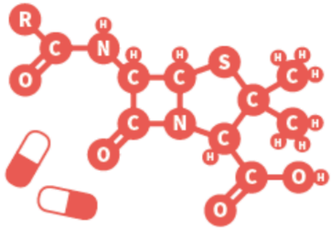
Science plays a vital role in our health, safety, economies, and governments. Here are just some of the ways chemistry impacts your everyday life.

ANAESTHETICS



We take surgery under anaesthesia for granted today, but the first anaesthetics were only discovered in the mid-1800s. Subsequently chemists have made many more.

ANTIBIOTICS

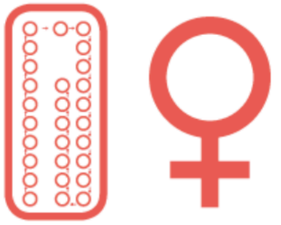


Bacterial infections were a common cause of death until antibiotics became available the 1930s. Chemists have since discovered numerous classes of antibiotics.

BATTERIES

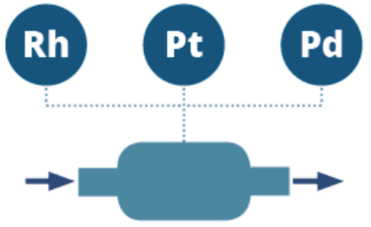
Both alkaline batteries and the lithium batteries in your phone were developed by chemists, and they're still working on making improvements to them.

BIRTH CONTROL



The first oral contraceptives became available in the 1960s after chemists developed synthetic compounds that could affect hormone levels in the body.

CATALYTIC CONVERTERS



Catalytic converters, developed in the 1960s and 70s, convert toxic gases and pollutants in car exhaust gas into less harmful emissions, helping to reduce pollution.

FERTILISERS

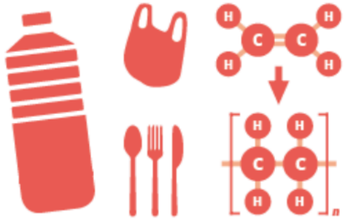
$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

The Haber process, developed in the early 1900s, creates 450 million tons of nitrogen fertiliser per year. This is vital for growing food and supporting the world's population.

FUELS

Petrol and diesel extracted from crude oil currently fuel the majority of our cars. Chemists are also investigating cleaner alternatives, such as hydrogen fuels.

PLASTICS

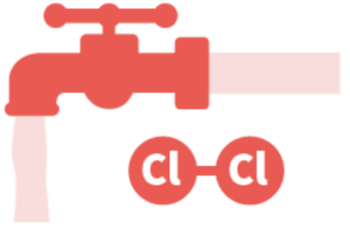


Plastics are everywhere in our day-to-day lives. Over the years chemists have developed a range of plastics for different uses, including clothing and food packaging.

SCREENS

If you're reading this on a screen, you have chemists to thank. Different types of screens and touch screens all rely on materials developed by chemists to work.

WATER TREATMENT



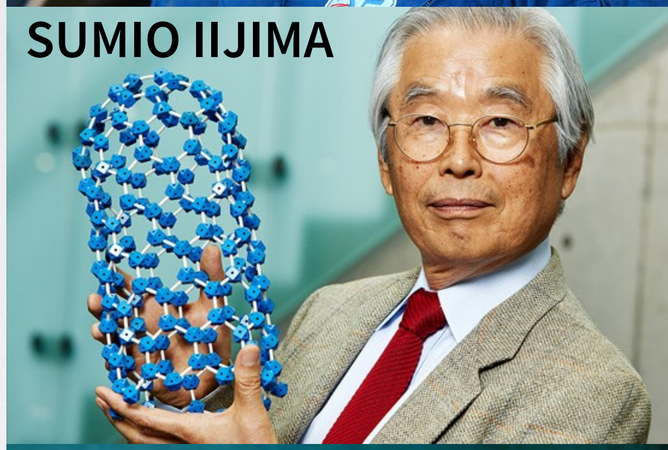
Water chlorination began in the early 1900s and kills bacteria and microbes, helping prevent the spread of diseases such as cholera. It also keeps swimming pools clear!

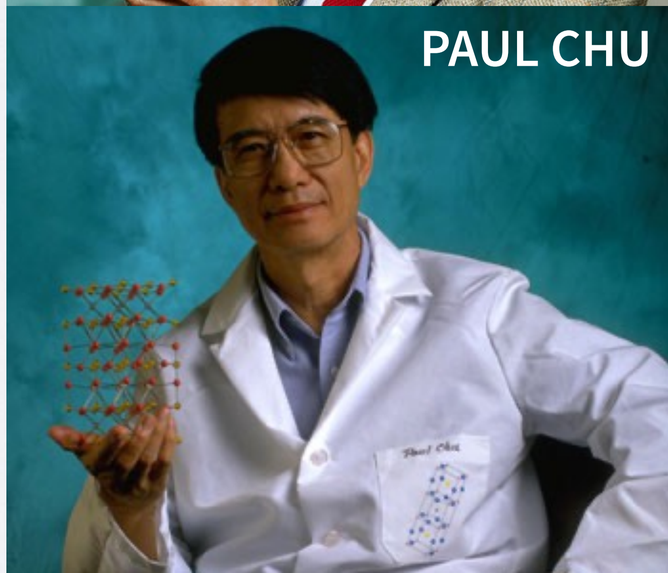
MATERIALS ENGINEERS

- **Leland Melvin**
  BS Chemistry, University of Richmond
  MS Materials Science, University of Virginia
  11th round draft pick, Detroit Lions 1986
  565 hours in space (2 shuttle missions)

- **Sumio Iijima**
  BS Engineering, University of Electro-Communications (Tokyo)
  MS, PhD Physics, Tohoku University
  Discovered the atomic structure and helical character of multi-wall and single-wall carbon nanotubes

- **Paul (Ching-Wu) Chu**
  BS Physics, Taiwan Provincial Cheng Kung University
  MS Physics, Fordham University
  PhD Physics, University of California, San Diego
  First scientist to demonstrate high-temperature superconductivity





GRAPHITE

The Driving Force Behind Green Technology

LOMIKO METALS

6 C Carbon

15th most abundant element in the Earth's crust

Carbon occurs naturally in **3** forms:

DIAMONDS

AMORPHOUS
Coal, charcoal, etc

GRAPHITE

GRAPHITE FACTS

Highest natural strength / stiffness of any material	Lightest weight of all reinforce-ments	Corrosion and heat resistant	An excellent conductor of electricity and heat	An excellent lubricant

Demand for flake graphite is being driven upwards by green technology

Occurs in **3** forms:

FLAKE

Lump / Vein

Amorphous

THE GRAPHITE MARKET

SUPPLY

70% of the world's graphite market.

40% Flake Graphite

60% Amorphous Graphite

Highest price Lowest supply

High purity crystal flake graphite supply is very limited. Only this kind of natural graphite can be used for Li-ion batteries, fuel cells, and other green tech.

High Carbon Purity — Large Flake Size

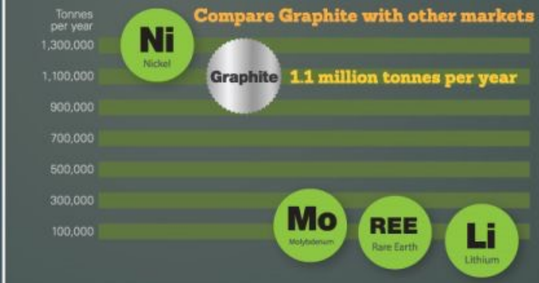
Carbon Flake Purity directly affects the price of the resource

DEMAND

5% growth in the last decade.
Driven by Asian steel and auto markets

USD $12,000,000,000
(Estimated worldwide Graphite market in 2011)

Compare Graphite with other markets



GREEN TECHNOLOGY

DRIVING GRAPHITE DEMAND

LITHIUM ION BATTERIES

Lithium ion batteries are found in many modern electronic devices.

In a Li-ion battery, graphite is used as the anode.

In the near future, use of electric cars will increase dramatically. **Electric car batteries** contain a significant amount of graphite.

For example:

Graphite use in **kgs**

FACT

There is actually **10–20x** more graphite in a Lithium Ion battery than Lithium

15g
The amount of graphite in a smartphone battery

3 MILLION•
The number of electric vehicles expected to be in use by 2017

FUEL CELLS

Fuel Cells have the potential to use as much graphite as all other uses.*

Proton Exchange Membrane technology requires large amounts of graphite, and is the most likely technology to be developed for use in light vehicles, buildings, and smaller applications.†

*US Geological Survey
†US Department of Energy

NUCLEAR POWER

China is currently developing and testing **Pebble Bed reactor designs**.* In April 2011, China began building a 210 MW fourth-generation nuclear reactor using high temperature gas-cooled Pebble Bed technology.

CHINA is aiming to exponentially expand its nuclear power program:

FACT

A 1GW Pebble Bed Reactor needs 3,000 tonnes of graphite to start up and up to 1,000 tonnes to operate annually

GRAPHENE

Graphite flakes are made of many layers of **graphene** stacked on top of each other, with weak bonds holding them together.

Carbon atoms arranged in a honeycomb pattern can be arranged in sheets that are only one atom thick.

1mm is the thickness of **3 million** stacked sheets of graphene

Research has shown that GRAPHENE has unique properties:

1000x the electrical current capacity of Copper wire
200x stronger than structural steel
10x better heat conductivity than Copper
20% flexibility without any damage

Graphene could make technology thinner, transparent, flexible, and more powerful.

EMERGING DISCIPLINES

- What's an example of an old (ancient, even) engineering field of study (or application)?
- What's an example of a now-established engineering discipline that did not exist 150 years ago?
- What's an example of a currently emerging field of engineering?

LEARNERS TO EARNERS

Engineering occupations consistently appear on lists of best-paying careers. In the September 2020 *U.S. News and World Report* ranking of college majors with the highest starting salaries, engineering degrees claimed nine of the top 10 slots (the remaining one: computer science). The U.S. Department of Labor's 2019 list of highest-paying careers ranked engineering occupations in five of the first 50 positions.

From 2018 to 2019, median engineering salaries increased 2 percent on average, according to the Bureau of Labor Statistics. Petroleum engineers commanded the highest median salary of the disciplines, at $137,720. Only architectural and engineering managers earned more, with a median salary of $144,830. The lowest median annual salary was $80,720 for agricultural engineers, the only category that did not beat the overall median salary for STEM professionals of $86,980.

Engineering technician and technologist median salaries* also showed a slight increase from 2018 to 2019—1 percent on average. In 2019, the median annual salary for these positions ranged from $45,010 for surveying and mapping technicians to $66,020 for aerospace engineering technicians and technologists.

*Source: U.S. Bureau of Labor Statistics (BLS), Occupational Employment Statistics. *The data combining engineering technicians and technologists are reported as provided by the BLS.*

Agricultural Engineers	5%	$80,720 USD
Architectural & Engineering Managers	3%	$144,830 USD
All Other Drafters	2%	$52,830 USD
Electrical & Electronics Drafters	2%	$61,530 USD
Aerospace Engineers	1%	$116,500 USD
Materials Engineers	1%	$93,360 USD
Civil Engineers	0%	$87,060 USD
Environmental Technologists & Technicians	0%	$50,620 USD
Marine Engineers and Naval Architects	0%	$92,400 USD
Aerospace Engineering Technologists & Technicians	-1%	$66,020 USD
Mining & Geological Engineers, Including Safety Engineers	-1%	$91,160 USD
All Other ETs & Technicians, Except Drafters	-6%	$59,620 USD
Nuclear Engineers	5%	$113,460 USD
Biomedical Engineers	3%	$91,410 USD
All Other Engineers	2%	$99,040 USD
Electrical Engineers	2%	$98,530 USD
Electrical & Electronics Technologists & Technicians	1%	$65,260 USD
Mechanical Engineering Technologists & Technicians	1%	$56,980 USD
Petroleum Engineers	0%	$137,720 USD
Chemical Engineers	4%	$108,770 USD
Electronics Engineers, Excludes Computers	3%	$105,570 USD
Civil Engineering Technologists & Technicians	2%	$53,410 USD
Industrial Engineering Technologists & Technicians	2%	$56,550 USD
Electro-Mechanical Technologists & Technicians	1%	$58,350 USD
Mechanical Engineers	1%	$88,430 USD
Architectural & Civil Drafters	3%	$56,340 USD
Health and Safety Engineers, Except Mining Safety	3%	$91,410 USD
Computer Hardware Engineers	2%	$117,220 USD
Mechanical Drafters	2%	$57,060 USD
Environmental Engineers	1%	$88,860 USD
Surveying & Mapping Technicians	1%	$45,010 USD

KEY

ENGINEERING TECHNOLOGY

FIELD | % Change

SALARY USD

ENGINEERING

Upward Climb

Engineering and engineering technology employment will grow in the coming decade, though not as rapidly as the overall science, technology, engineering, and mathematics (STEM) workforce, according to the latest U.S. Bureau of Labor Statistics (BLS) estimates. Engineering jobs, which include positions filled by both engineering and engineering technology degree holders, will see a 5 percent increase, from 2,019,300 in 2018 to 2,115,100 by 2028. Engineering technician jobs, which typically require a two-year degree, will grow by 2 percent over the decade, from 701,300 in 2018 to 712,800 in 2028. BLS does not have a job category for computer science, instead listing computational and mathematical occupations. But those two fields will be the main drivers of an overall 9 percent growth in STEM occupations, from 9,708,300 jobs in 2018 to 10,566,800 jobs in 2028. Computational jobs will increase by 12 percent and mathematical jobs by 26 percent during the decade to accommodate the growing application of machine learning and AI technology in industry.

Data source: United States Bureau of Labor Statistics Employment Projections released September 2019

9% Environmental Engineering Technicians

+5% Drafters, All Others

+5% Surveying / Mapping Technicians

+5% Civil Engineering Technicians

+5% Aerospace Engineering/ Operations Technicians

+4% Electrical and Electronics Drafters

Occupation (Engineering Technicians/Technologists)	2018	2028
Architectural and Civil Drafters	101,200	103,000
Electrical and Electronics Drafters	25,600	26,500
Mechanical Drafters	58,000	54,000
Drafters, All Others	15,000	15,700
Aerospace Engineering/ Operations Technicians	10,500	11,000
Civil Engineering Technicians	73,800	77,400
Electrical and Electronics Engineering Technicians	130,500	130,700
Electro-mechanical Technicians	14,000	14,100
Environmental Engineering Technicians	17,900	19,500
Industrial Engineering Technicians	68,300	67,800
Mechanical Engineering Technicians	42,600	43,800
Engineering Technicians, (Except Drafters) All Other	87,100	89,400
Surveying and Mapping Technicians	56,800	59,900

+3% Mechanical Engineering Technicians

+3% Engineering Technicians (All Other)

+2% Architectural/ Civil Drafters

+1% Electro-Mechanical Technicians

0% Electrical/ Electronics Engineering Technicians

Industrial Engineering Technicians -1%

-7% Mechnical Drafters

KEY

Engineering Technology

Engineering

Growth

No Change

Decline

+11% Engineering Teachers (Postsecondary)

+9% Marine Engineers/ Naval Architects

+8% Agricultural Engineers

+8% Industrial Engineers

+6% Computer Hardware Engineers

+6% Civil Engineers

+6% Chemical Engineers

+5% Environmental Engineers

+4% Biomedical Engineers

+5% Electrical Engineers

+4% Mechanical Engineers

+5% Health/Safety Engineers

Occupation (Engineering)	2018	2028
Architectural/Engineering Managers	192,500	197,900
Aerospace Engineers	67,200	68,300
Agricultural Engineers	2,600	2,800
Biomedical Engineers	19,800	20,500
Chemical Engineers	33,900	36,000
Civil Engineers	326,800	347,300
Computer Hardware Engineers	64,400	68,400
Electrical Engineers	191,900	201,100
Electronics Engineers (No Computers)	138,500	137,300
Environmental Engineers	55,400	58,300
Health and Safety Engineers	27,000	28,400
Industrial Engineers	284,600	308,800
Marine Engineers/ Naval Architects	11,700	12,700
Materials Engineers	27,700	27,700
Mechanical Engineers	312,900	325,700
Mining and Geo Engineers	5,900	6,100
Nuclear Engineers	17,700	17,600
Petroleum Engineers	33,500	34,300
Engineering Teachers (Postsecondary)	47,500	52,800

3% Mining/Geo Engineers

+3% Architectural/ Engineering Managers

+2% Petroleum Engineers

+2% Aerospace Engineers

0% Materials Engineers

Electronics Engineers -1%

Nuclear Engineers -1%

DESIGN BY TONI RIGOLOSI

Certified Professional ENGINEER (PE)
SALARY & BENEFITS

School of PE™

Salary Ranges By Job

(Individuals Reporting: 10,390)

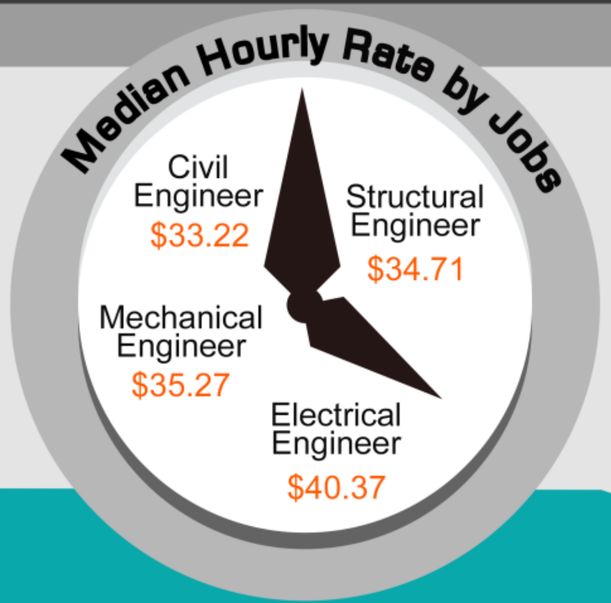
- Mechanical Engineer: $57,541 - $107,279
- Electrical Engineer: $59,139 - $116,738
- Civil Engineer: $54,743 - $100,740
- Structural Engineer: $57,827 - $99,542

Median Bonus By Jobs

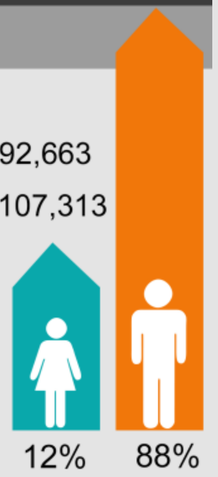
(Individuals Reporting: 6,034)

- Civil Engineer: $1,962
- Electrical Engineer: $3,847
- Mechanical Engineer: $2,942
- Structural Engineer: $2,250

Median Hourly Rate by Jobs



- Salary: $66,282 - $92,663
- Salary: $70,181 - $107,313



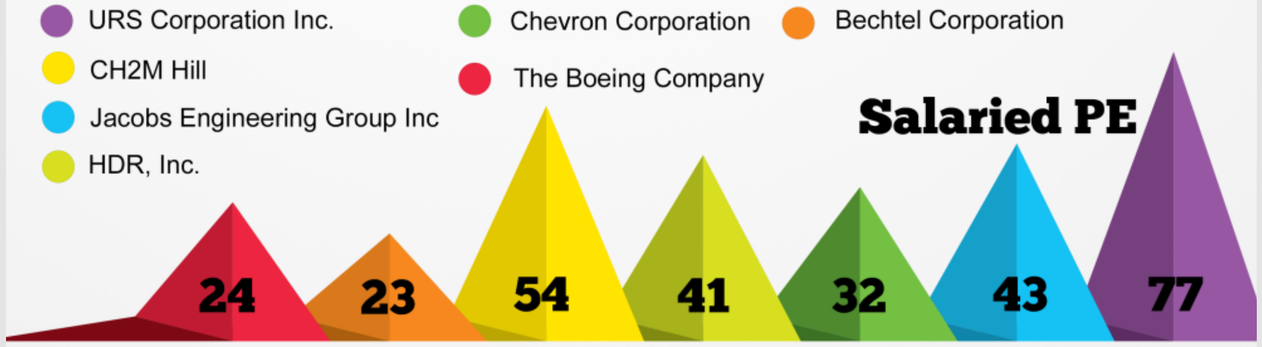
(Individuals Reporting: 1,243)

SALARY RANGE OF COMPANIES EMPLOYING A PE

- Shell Oil Company: $93,187 - $244,679
- ExxonMobil Corporation: $91,089 - $184,936
- British Petroleum (BP): $90,042 - $214,470
- General Electric Co (GE): $89,306 - $164,622
- KBR: $88,388 - $184,000
- U.S. Air Force(USAF): $88,388 - $184,000
- Bechtel Corporation: $81,174 - $162,090

(Individuals Reporting: 4,437)

COMPANIES EMPLOYING PE



Source:http://www.payscale.com/research/US/Certification=Certified_Professional_Engineer_%28PE%29/Salary

Country: United States | Currency: USD | Updated: 22 Nov 2014

WHO LOOKS LIKE AN ENGINEER?

We ALL look like engineers

#I LOOK LIKE AN ENGINEER

ENGINEERING SKILLS

Pick two: Take five minutes and write a few sentences about why employers want those particular skills.

1. Team Player

Teamwork drives the successful completion of a project. No one can complete a project on their own. They need others to contribute.

2. Continuous Learning

Technology and methodologies are constantly changing. Staying up to date with the latest developments puts you ahead of the field.

3. Creativity

It may sound cliché, but successful engineers have an innate ability to "think outside the box".

4. Problem Solving

Any project, no matter how big or small, will face problems. An engineer must be able to effectively address these as they arise.

5. Analytical Ability

Engineers are required to think analytically in order to fully define a problem and develop solutions suited to the problem.

6. Communication Skills

For an engineer, communication means the ability to not only understand technical complexities, but the ability to succinctly and effectively translate technical jargon into layman's terms without patronising others.

7. Logical Thinking

An engineer must know how the system works, what can go wrong and how to fix it. This requires an ability to think logically, and evaluate and understand each element that makes up the system.

8. Attention to Detail

Successful engineers pay meticulous attention to the smallest of details.

9. Mathematical Ability

To be a successful engineer you must have outstanding math skills.

10. Leadership

Successful engineers also need well-developed "soft skills" so they can smoothly perform non-technical duties.

SOFT SKILLS ARE SKILLS, TOO

7 Personality Traits and Qualities of a Engineer Leader

An Engineering Skill Set Checklist

The professionals who excel in the industry typically display these seven engineering personality traits and qualities.

How many of these engineering skills and qualities apply to you?

Critical Thinkers

Instead of performing only your role in a project, you'll need to have a bigger-picture mentality and demonstrate a deeper understanding of the work that should be done.

Can you harness your team for an integrated effort? Do you understand *all* components of the project?

Original

As a leader, you'll need to think beyond what's been done before. Is there a better way to do the work? What hasn't been tried yet?

Keep up with the new best practices in the field and adapt them to the opportunities and needs of your organization.

Driven

Stuck? Daunted? "Can't"? None of these words apply to you as an engineering executive.

You need to *make* it happen, whatever it is, and you can't let road-blocks get in the way of achieving your goals.

Receptive

How open are you to new ideas? You'll need to be ready to hear suggestions and thoughts from your team. You'll also need to be able to accept that your way won't always be the best way for everyone.

You may be the executive, but your team needs to have a say too.

Responsive

As an engineering executive, you'll be in charge of big projects and big decisions. You'll need to be able to think on your feet when problems arise or new information comes to light.

Think fast!

Team Oriented

You'll be a leader on a team working towards a common goal. How well do you work with others? Can you handle and direct strong personalities in the group? Do you know how to delegate tasks?

Courtesy and tact go a long way towards helping your team trust you.

Constant Learners

Keeping your technical skills strong is a must—you'll need to work with new technologies and computer programs constantly and then teach your team to embrace the changes.

Maintaining your skills and a fresh knowledge of the field is especially important when managing multiple projects simultaneously!

7 SOFT SKILLS TO ADVANCE YOUR ENGINEERING CAREER

Engineers are great at solving problems but often lack soft skills. Here are some useful tips needed to advance your career.

COMMUNICATION: It is the most important skill to pick up for a successful career. Practice being more social.

PRESENTATION: Avoid jargon. Work on simplifying and crisply explaining concepts.

SELF-CONFIDENCE: It is all about showing what you're capable of doing. Do new things. Take on a new challenge.

HUMILITY: Overconfidence could sink an engineer. Humility is important.

RESILIENCE: Don't give in when something negative happens. Be resilient and continue pursuing your goals.

EMPATHY: Be in tune with a customer's needs and understand what they want.

BRAND IDENTITY: Figuring out a personal identity and creating a brand around it is important. Don't be just an engineer.

SEE MORE TIPS ON ADVANCING YOUR ENGINEERING CAREER:
HTTP://BIT.LY/SOFTSKILLSASME

MECHANICAL ENGINEERING
THE MAGAZINE OF ASME