EP145 Introduction to Engineering

Topic 2

Overview of Engineering Disciplines

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Engineering Disiplines

- Engineering, is a broad discipline which is often broken down into several sub-disciplines.
- There are more than 20 engineering disciplines recognized by the professional societies [1-2].
- However, most engineering degrees are granted in **civil**, **electrical**, and **mechanical** engineering.

Engineering is around us

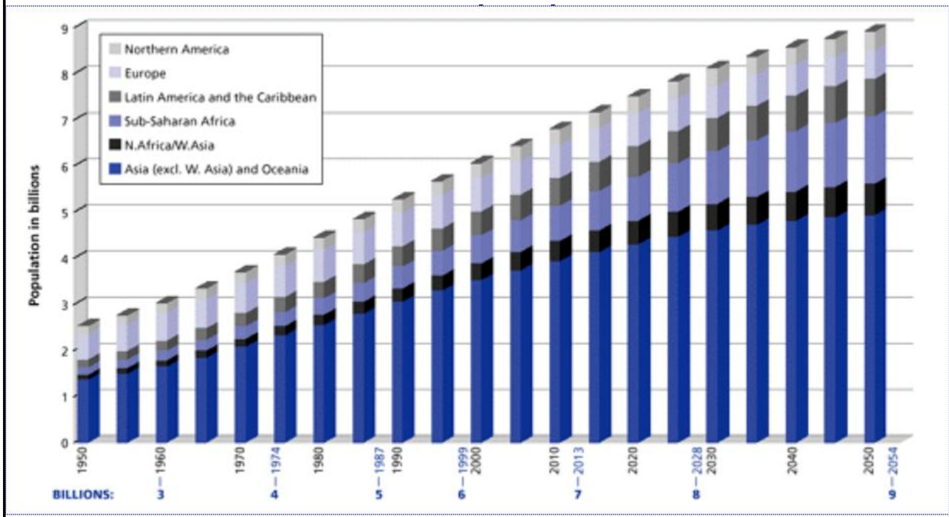
- Engineers make products and provide services that make our lives better.
- Engineers apply physical and chemical laws and principles and mathematics to design millions of products and services that we use in our everyday lives.

Engineers Deal with an Increasing World Population

People needs the following:

- food, clothing, shelter, and water for drinking or cleaning purposes.
- various modes of transportation to get to different places
- some sense of security

Worldwide socioeconomic population trends, environmental concerns, and the earth’s finite resources, more is expected of engineers!



Projected World Population Growth

Engineering Employment

Total, All Engineers	1,572,100	100%
Civil	278,400	17.7
Mechanical	238,700	15.2
Industrial	214,800	13.7
Electrical	157,800	10.0
Electronics, except computer	143,700	9.1
Computer hardware	74,700	4.8
Aerospace	71,600	4.6
Environmental	54,300	3.5
Chemical	31,700	2.0
Health and safety, except mining safety	25,700	1.6
Materials	24,400	1.6
Petroleum	21,900	1.4
Nuclear	16,900	1.1
Biomedical	16,000	1.0
Marine engineers and naval architects	8,500	0.5
Mining and geological, including mining safety	7,100	0.5
Agricultural	2,700	0.2
All other engineers	183,200	11.7

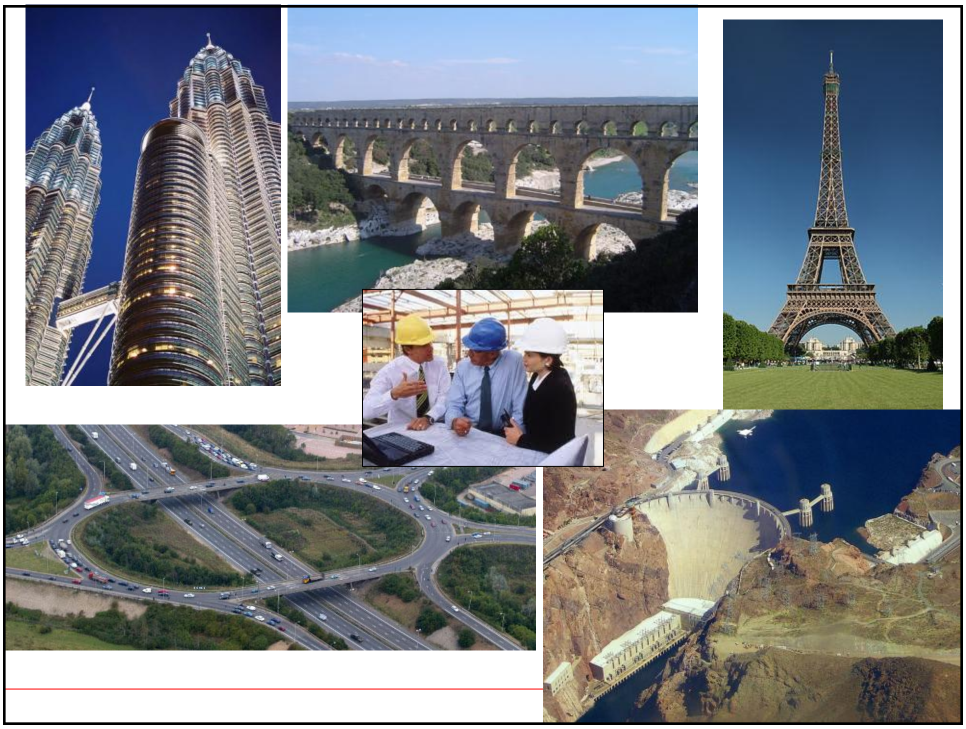
Source: Data from U.S. Bureau of Labor Statistics

Disciplines or Specialties	Average Salary
Aerospace/aeronautical/astronautical	$56,311
Agricultural	54,352
Bioengineering and biomedical	54,158
Chemical	64,902
Civil	52,048
Computer	61,738
Electrical/electronics and communications	60,125
Industrial/manufacturing	58,358
Materials	57,349
Mechanical	58,766
Mining and mineral	64,404
Nuclear	61,610

Source: Data from U.S. Bureau of Labor Statistics

Civil Engineering

- is the oldest engineering discipline!
- deals with designing and supervising the construction of buildings, roads and highways, bridges, dams, tunnels, mass transit systems, airports, municipal water supplies and sewage systems.
- is grouped into seven major divisions:
  - Structural
  - Environmental
  - Geotechnical
  - Water Resources
  - Transportation, Construction
  - Urban Planning

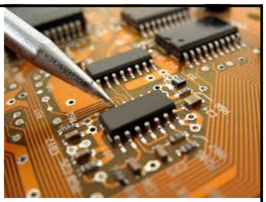


More on Civil Engineering

From the pyramids of Egypt to the space station Freedom, civil engineers have always faced the challenges of the future, advancing civilization and building our quality of life. Today, the world is undergoing vast changes: the technological revolution, population growth, environmental concerns, and more. All create unique challenges for civil engineers of every specialty. The next decades will be the most creative, demanding, and rewarding of times for civil engineers.

Today, civil engineers are in the forefront of technology. They are users of sophisticated high-tech products, applying the very latest concepts in computer aided design (CAD) during design, construction, project scheduling, and cost control. Civil engineering is about community service, development, and improvement—the planning, design, construction, and operation of facilities essential to modern life, ranging from transit systems to offshore structures to space satellites. Civil engineers are problem solvers, meeting the challenges of pollution, traffic congestion, drinking water and energy needs, urban redevelopment, and community planning. Our future as a nation will be closely tied to space, energy, the environment, and our ability to interact with and compete in the global economy. Civil engineers will perform a vital role in linking these themes and improving quality of life for the 21st century. As the technological revolution expands, as the world's population increases, and as environmental concerns mount, civil engineers' skills will be needed.

Electrical & Electronical Eng.

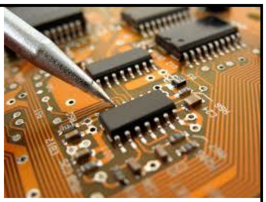


- EEE is the largest engineering discipline!

- **Electrical Engineers**
  design, develop, test, and supervise
  - the manufacturing of electrical equipment, including lighting and wiring for buildings, cars, buses, trains, ships, and aircrafts
  - power generation and transmission equipment for utility companies
  - electric motors found in various products;
  - control devices
  - radar equipment

- Major branches of **Electrical Engineering**
  - power generation
  - power transmission and distribution
  - controls

- **Electronical Engineers**
  design, develop, test, and supervise
  - the production of electronic equipment including computer hardware
  - computer network hardware
  - communication devices such as cellular
  - phones, television, and audio and video equipment
  - measuring instruments.



- Major branches of **Electronical Engineering**
  - Computer
  - Telecommunications
  - semiconductor technology (ICs)

More on EEE

Electrical and electronics engineers conduct research, and design, develop, test, and oversee the development of electronic systems and the manufacture of electrical and electronic equipment and devices. From the global positioning system that can continuously provide the location of a vehicle to giant electric power generators, electrical and electronics engineers are responsible for a wide range of technologies. Electrical engineering has many subfields, some of the most common of which we outline below.

Telecommunications is a prime growth area for electrical/electronics engineers. This includes developing services for wired and wireless networks for homes and businesses, as well as satellite, microwave, and fiber networks that form the backbone of the civil and military communications infrastructure.

Power engineers deal with energy generation by a variety of methods, such as turbine, hydro, fuel cell, solar, geothermal, and wind. They also deal with electrical power distribution from source to consumer and within factories, offices, hospitals, laboratories, and they design electric motors and batteries. In industry, power engineers are employed wherever electrical energy is used to manufacture or produce an end product. They are needed to design electrical distribution systems and instrumentation and control systems for the safe, effective, efficient operation of the production facilities.

The computer industry serves many sectors, and electrical engineers play a major role. Electrical engineering has strong connections to computer engineering, and at many universities, the computer engineering and electrical engineering programs reside in the same department. The chief enabling technology at the heart of the electronic components booming computer industry is semiconductor technology, in particular the development and manufacture of integrated circuits.

Mechanical Engineering

- is one of the broadest engineering disciplines!
- Mechanical engineers are involved in the design, development, testing, and manufacturing of
  - machines
  - robots
  - tools
  - power generating equipment (such as steam and gas turbines)
  - heating, cooling, and refrigerating equipment
  - internal combustion engines
- The major branches include
  - thermal /fluid systems
  - structural /solid systems

More on Mechanical Engineering

Mechanical engineers use the principles of energy, materials, and mechanics to design and manufacture machines and devices of all types. They create the processes and systems that drive technology and industry.

The key characteristics of the profession are its breadth, flexibility, and individuality. The career paths of mechanical engineers are largely determined by individual choices, a decided advantage in a changing world. Mechanics, energy and heat, mathematics, engineering sciences, design and manufacturing form the foundation of mechanical engineering. Mechanics includes fluids, ranging from still water to hypersonic gases flowing around a space vehicle; it involves the motion of anything from a particle to a machine or complex structure.

Mechanical engineers research, develop, design, manufacture, and test tools, engines, machines, and other mechanical devices. They work on power-producing machines such as electric generators, internal combustion engines, and steam and gas turbines, as well as power using machines such as refrigeration and airconditioning equipment, machine tools, material handling systems, elevators and escalators, industrial production equipment, and robots used in manufacturing. Mechanical engineers also design tools that other engineers need for their work. Mechanical engineering is one of the broadest engineering disciplines. Mechanical engineers may work in production operations in manufacturing or agriculture, maintenance, or technical sales; many are administrators or managers.

Aerospace Engineering

- design, develop, test, and supervise the manufacture of
  - commercial and military aircraft
  - helicopters
  - spacecraft
  - missiles
- They may work on projects dealing with research and development of guidance, navigation, and control systems.
- Most aerospace engineers work for
  - aircraft and missile manufacturers,
  - the Department of Defense,
  - NASA (USA)
  - ASELSAN (TR)

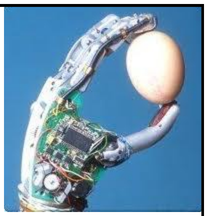
More on Aerospace Engineering

Aerospace engineers create machines, from airplanes that weigh over a half a million pounds to spacecraft that travel over 17,000 miles an hour. They design, develop, and test aircraft, spacecraft, and missiles and supervise the manufacture of these products. Aerospace engineers who work with aircraft are called aeronautical engineers, and those working specifically with spacecraft are astronautical engineers.

Aerospace engineers develop new technologies for use in aviation, defense systems, and space exploration, often specializing in areas such as structural design, guidance, navigation and control, instrumentation and communication, or production methods. They often use computer-aided design (CAD) software, robotics, and lasers and advanced electronic optics. They also may specialize in a particular type of aerospace product, such as commercial transports, military fighter jets, helicopters, spacecraft, or missiles and rockets.

Aerospace engineers may be experts in aerodynamics, thermodynamics, celestial mechanics, propulsion, acoustics, or guidance and control systems. Aerospace engineers typically are employed in the aerospace product and parts industry, although their skills are becoming increasingly valuable in other fields. For example, in the motor vehicles manufacturing industry, aerospace engineers design vehicles that have lower air resistance and, thus, increased fuel efficiency.

Biomedical Engineering



- is a new discipline that combines biology, chemistry, medicine, and engineering to solve a wide range of medical and health-related problems.
- They apply the laws and the principles of chemistry, biology, medicine, and engineering to design
  - artificial limbs
  - organs
  - medical imaging systems and devices
- The major branches include
  - biomechanics
  - biomaterials
  - tissue engineering
  - medical imaging
  - rehabilitation

More on Biomedical Engineering

By combining biology and medicine with engineering, biomedical engineers develop devices and procedures that solve medical and health related problems. Many do research, along with life scientists, chemists, and medical scientists, to develop and evaluate systems and products for use in the fields of biology and health, such as artificial organs, prostheses (artificial devices that replace missing body parts), instrumentation, medical information systems, and health management and care delivery systems.

Bioengineers engineers design devices used in various medical procedures, such as the computers used to analyze blood or the laser systems used in corrective eye surgery. They develop artificial organs, imaging systems such as magnetic resonance, ultrasound, and x-ray, and devices for automating insulin injections or controlling body functions. Most engineers in this specialty require a sound background in one of the basic engineering specialties, such as mechanical or electronics engineering, in addition to specialized biomedical training. Some specialties within bioengineering or biomedical engineering include biomaterials, biomechanics, medical imaging, rehabilitation engineering, and orthopedic engineering.

Approximately 40% of biomedical engineers work for companies that manufacture products, primarily in the pharmaceutical and medicine manufacturing, and medical instruments and supplies industries. Many others worked for hospitals. Some also worked for government agencies or as independent consultants.

Chemical Engineering

- use the principles of chemistry and basic engineering sciences to solve a variety of problems related to production of chemicals their use in various industries, including the pharmaceutical, electronic, and photographic industries.
- The major branches include
  - chemical and petroleum refining
  - film
  - paper
  - plastic
  - paint
  - soap
  - food processing
  - biotechnology
  - fermentation

More on Chemical Engineering

Chemical engineers work in manufacturing, pharmaceuticals, healthcare, design and construction, pulp and paper, petrochemicals, food processing, specialty chemicals, polymers, biotechnology, and environmental health and safety industries, among others. Within these industries, chemical engineers rely on their knowledge of mathematics and science, particularly chemistry, to overcome technical problems safely and economically. And, of course, they draw upon and apply their engineering knowledge to solve any technical challenges they encounter. Their expertise is also applied in the area of law, education, publishing, finance, and medicine, as well as many other fields that require technical training.

Specifically, chemical engineers improve food processing techniques, and methods of producing fertilizers, to increase the quantity and quality of available food. They also construct the synthetic fibers that make our clothes more comfortable and water resistant; they develop methods to mass-produce drugs, making them more affordable; and they create safer, more efficient methods of refining petroleum products, making energy and chemical sources more productive and cost effective. They also develop solutions to environmental problems, such as pollution control and remediation.

Computer Engineering

- Computer Engineering, Computer Science, and Software Engineering are three closely related fields that focus upon developing the technology upon which so many other disciplines depend.
- Computer engineers analyze, design, and evaluate computer systems, both hardware and software.
- They might work on system such as
  - flexible manufacturing system
  - smart device or instrument
  - embeded device or instrument

More on Computer Engineering

Computer engineering is a discipline that integrates several fields of electrical engineering and computer science required to develop computer systems.

Computer engineers often find themselves focusing on problems or challenges which result in new state-of-theart products, which integrate computer capabilities. They work on the interface between different pieces of hardware and strive to provide new capabilities to existing and new systems or products. The work of a computer engineer is grounded in the hardware—from circuits to architecture—but also focuses on operating systems and software. Computer engineers must understand logic design, microprocessor system design, computer architecture, computer interfacing, and continually focus on system requirements and design. It is primarily software engineers who focus on creating the software systems used by individuals and businesses, but computer engineers may also design and develop some software applications.

Computer scientists impact society through their work in many areas. Because computer technology is embedded in so many products, services, and systems, computer scientists can be found in almost every industry. Design of next generation computer systems, computer networking, biomedical information systems, gaming systems, search engines, web browsers, and computerized package distribution systems are all examples of projects a computer scientist might work on. Computer scientists might also focus on improving software reliability, network security, information retrieval systems, or may even work as a consultant to a financial services company.

Computer software engineers apply the principles and techniques of computer science, engineering, and mathematical analysis to the design, development, testing, and evaluation of the software and systems that enable computers to perform their many applications.

Environmental Engineering

- is concerned with solving problems related to the environment.

- Environmental engineers apply the laws and the principles of chemistry, biology and engineering to address issues related to
  - water and air pollution control
  - hazardous waste
  - waste disposal
  - recycling
  - acid rain
  - global warming
  - automobile emissions
  - ozone depletion

More on Computer Engineering

Using the principles of biology and chemistry, environmental engineers develop solutions to environmental problems. They are involved in water and air pollution control, recycling, waste disposal, and public health issues. Environmental engineers conduct hazardous-waste management studies in which they evaluate the significance of the hazard, offer analysis on treatment and containment, and develop regulations to prevent mishaps. Environmental engineers are concerned with local and worldwide environmental issues. They study and attempt to minimize the effects of acid rain, global warming, automobile emissions, and ozone depletion. They also are involved in the protection of wildlife.

Environmental engineers' job duties include collecting soil or groundwater samples and testing them for contamination; designing municipal sewage and industrial wastewater systems; analyzing scientific data; researching controversial projects; and performing quality control checks. They may be involved in legal or financial consulting regarding environmental processes or issues. They may study and attempt to minimize the effects of large-scale problems such as acid rain, global warming, and ozone depletion. Many environmental engineers work as consultants, helping their clients to comply with regulations and to clean up hazardous sites.

Industrial Engineering

- is dealing with the optimization of complex processes or systems.
- is concerned with the development, improvement, implementation and evaluation of integrated systems of
  - people
  - money
  - knowledge
  - information
  - equipment
  - energy
  - materials
  - analysis
  - synthesis

More on Industrial Engineering

Industrial engineers determine the most effective ways to use the basic factors of production (people, machines, materials, information, and energy) to make a product or to provide a service. They are the bridge between management goals and operational performance. They are more concerned with increasing productivity through the management of people, methods of Business organization, and technology than are engineers in other specialties, who generally work more with products or processes. Although most industrial engineers work in manufacturing industries, they may also work in consulting services, healthcare, and communications.

To solve organizational, production, and related problems most efficiently, industrial engineers carefully study the product and its requirements, use mathematical methods such as operations research to meet those requirements, and design manufacturing and information systems. They develop management control systems to aid in financial planning and cost analysis and design production planning and control systems to coordinate activities and ensure product quality. They also design or improve systems for the physical distribution of goods and services. Industrial engineers determine which plant location has the best combination of raw materials availability, transportation facilities, and costs. Industrial engineers use computers for simulations and to control various activities and devices, such as assembly lines and robots. They also develop wage and salary administration systems and job evaluation programs. Many industrial engineers move into management positions because the work is closely related.

Manufacturing Engineering

- develop, coordinate, and supervise the process of manufacturing all types of products.

Manifacturing Engineers

- are concerned with making products efficiently and at minimum cost.
- are involved in all aspects of production,including scheduling and materials handling and the design, development, supervision, and control of assembly lines.
- employ robots and machine-vision technologies for production purposes.
- are employed by all types of industries, including
  - automotive
  - aerospace
  - food processing and packaging.

More on Manifacturing Engineering

Manufacturing engineers are involved with the process of manufacturing from planning to packaging of the finished product. They work with tools such as robots, programmable and numerical controllers, and vision system to fine tune assembly, packaging, and shipping facilities. They examine flow and the process of manufacturing, looking for ways to streamline production, improve turnaround, and reduce costs. Often, a manufacturing engineer will work with a prototype, usually created electronically with computers, to plan the final manufacturing process. In a globally competitive marketplace, it is the job of the manufacturing engineer to figure out methods and systems to produce a product in an efficient, cost-effective way to provide a marketing edge for the final product.

Petroleum Engineering

- deals with in the discovery and production of underground oil and natural gas reservoirs.

Petroleum Engineers

- are in collaboration with geologists who have a good understanding of the properties of the rocks that make up the earth's crust.
- are involved in monitoring and supervising drilling and oil extraction operations.
- use computer models to simulate reservoir performance as they experiment.with different recovery techniques.

More on Petroleum Engineering

Petroleum engineers search the world for reservoirs containing oil or natural gas. Once these resources are discovered, petroleum engineers work with geologists and other specialists to understand the geologic formation and properties of the rock containing the reservoir, determine the drilling methods to be used, and monitor drilling and production operations. They design equipment and processes to achieve the maximum profitable recovery of oil and gas. Petroleum engineers rely heavily on computer models to simulate reservoir performance using different recovery techniques. They also use computer models for simulations of the effects of various drilling options.

Because only a small proportion of oil and gas in a reservoir will flow out under natural forces, petroleum engineers develop and use various enhanced recovery methods. These include injecting water, chemicals, gases, or steam into an oil reservoir to force out more of the oil, and computer-controlled drilling or fracturing to connect a larger area of a reservoir to a single well. Because even the best techniques in use today recover only a portion of the oil and gas in a reservoir, petroleum engineers research and develop technology and methods to increase recovery and lower the cost of drilling and production operations.

Nuclear Engineering

- is to design, develop, monitor, and operate nuclear power equipment that derives its power from nuclear energy.

Nuclear Engineers

- are involved in the design, development, and operation of nuclear power plants to generate electricity or to power Navy ships and submarines.
- also work in the production and handling of nuclear fuel and the safe disposal of its waste products.

More on Nuclear Engineering

Nuclear engineers research and develop the processes, instruments, and systems for national laboratories, private industry, and universities that derive benefits from nuclear energy and radiation for society. They devise how to use radioactive materials in manufacturing, agriculture, medicine, power generation, and many other ways.

Many nuclear engineers design, develop, monitor, and operate nuclear plants used to generate power. They may work on the nuclear fuel cycle – the production, handling, and use of nuclear fuel and the safe disposal of waste produced by the generation of nuclear energy. Others research the production of fusion energy. Some specialize in the development of power sources for spacecraft that use radioactive materials. Others develop and maintain the nuclear imaging Technology used to diagnose and treat medical problems.

Mining Engineering

- deals with finding, extracting, and preparing coal for use by utility companies;

Minining Engineers

- look for metals (gold) and minerals (coal) to extract from the earth for use by various manufacturing industries.
- are involved in the development of new mining equipment.
- are in collaboration with geologists and metallurgical engineers.

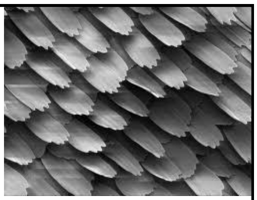
More on Mininig Engineering

Mining and geological engineers, including mining safety engineers, find, extract, and prepare coal, metals, and minerals for use by manufacturing industries and utilities. They design open-pit and underground mines, supervise the construction of mine shafts and tunnels in underground operations, and devise methods for transporting minerals to processing plants. Mining engineers are responsible for the safe, economical, and environmentally sound operation of mines.

Some mining engineers work with geologists and metallurgical engineers to locate and appraise new ore deposits. Others develop new mining equipment or direct mineral-processing operations that separate minerals from the dirt, rock, and other materials with which they are mixed.

Mining engineers frequently specialize in the mining of one mineral or metal, such as coal or gold. With increased emphasis on protecting the environment, many mining engineers work to solve problems related to land reclamation and water and air pollution. Mining safety engineers use their knowledge of mine design and practices to ensure the safety of workers and to comply with State and Federal safety regulations. They inspect walls and roof surfaces, monitor air quality, and examine mining equipment for compliance with safety practices.

Materials Engineering



- deals with research, development, and testing new materials to use in engineering applications such as
  - metal alloys
  - ceramics
  - plastics
  - composites

Materials Engineers

- study the nature, atomic structure, and thermo-physical properties of materials to create materials that are lighter, stronger, and more durable.
- produce materials with specific mechanical, electrical, magnetic, chemical, and heat-transfer properties for use in specific applications, for example, graphite tennis racquets that are much lighter and stronger than the old wooden racquets.

More on Materials Engineering

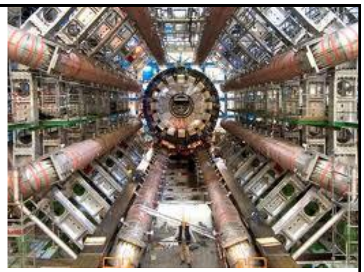
Materials Engineering is a field of engineering that encompasses the spectrum of materials types and how to use them in manufacturing. Materials span the range: metals, ceramics, polymers (plastics), semiconductors, and combinations of materials called composites. We live in a world that is both dependent upon and limited by materials.

Everything we see and use is made of materials: cars, airplanes, computers, refrigerators, microwave ovens, TVs, dishes, silverware, athletic equipment of all types, and even biomedical devices such as replacement joints and limbs. All of these require materials specifically tailored for their application. Specific properties are required that result from carefully selecting the materials and from controlling the manufacturing processes used to convert the basic materials into the final engineered product. Exciting new product developments frequently are possible only through new materials and/or processing.

New materials technologies developed through engineering and science will continue to make startling changes in our lives in the future, and people in materials science and engineering will continue to be key in these changes and advances. These engineers deal with the science and technology of producing materials that have properties and shapes suitable for practical use. You can find materials engineers working in aircraft manufacturing; various research and testing labs; and electrical, stone, and glass products manufacturers.

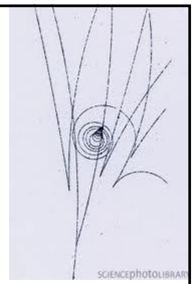
Other Engineering Fields

There are many engineering programs in other areas. These include:



- Architectural Engineering
- Ceramic Engineering
- Construction Engineering
- Drafting and Design
- Engineering (General)
- Engineering Management
- Engineering Mechanics
- Food Engineering
- Forest Engineering
- Geological Engineering
- Metallurgical Engineering
- Naval Architecture and Marine Engineering
- Ocean Engineering
- Plastics Engineering
- Social Engineering (security & political)
- Surveying Engineering
- Textile Engineering
- Welding Engineering

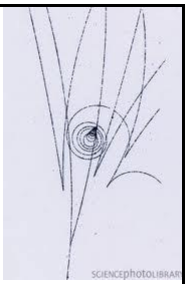
Engineering Physics or Engineering Science



- **Physics**
  is the '*King*' of the sciences and forms
  the foundation of engineering and technology.

- **Engineering Physics/Science**
  is the study of the combined disciplines based on
  physics, mathematics, statistics, and engineering principles.

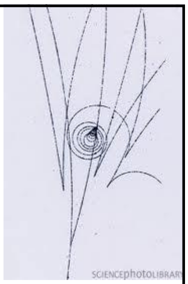
Engineering science/physics



is meant to provide a more thorough grounding in applied physics for a selected specialty such as:

- optics
- quantum physics
- materials science
- applied mechanics
- nanotechnology
- biophysics
- control theory
- aerodynamics
- energy
- solid-state physics
- nuclear physics
- particle physics
- etc...

Engineering Physics



- would be directly translated into English as "technical physics".
- bridges the gap between theoretical science and practical engineering.
- undergraduate programs
  - ***in Türkiye***: Istanbul Teknik Üniversitesi, Hacettepe Üniversitesi, Ankara Üniversitesi, Gaziantep Üniversitesi
  - ***in USA***: University of Toronto, Simon Fraser University, Pennsylvania State University

CERN

- *Conseil Européen pour la Recherche Nucléaire*

European Organization for Nuclear Research

Avrupa Nükleer Araştırma Merkezi

- **CERN is the world's largest particle physics laboratory, situated in the northwest suburbs of Geneva on the Franco–Swiss border, established in 1954.**

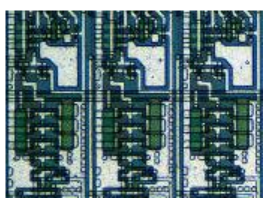
Particle Physics Applications

Medicine

Research

Education

Computer Science

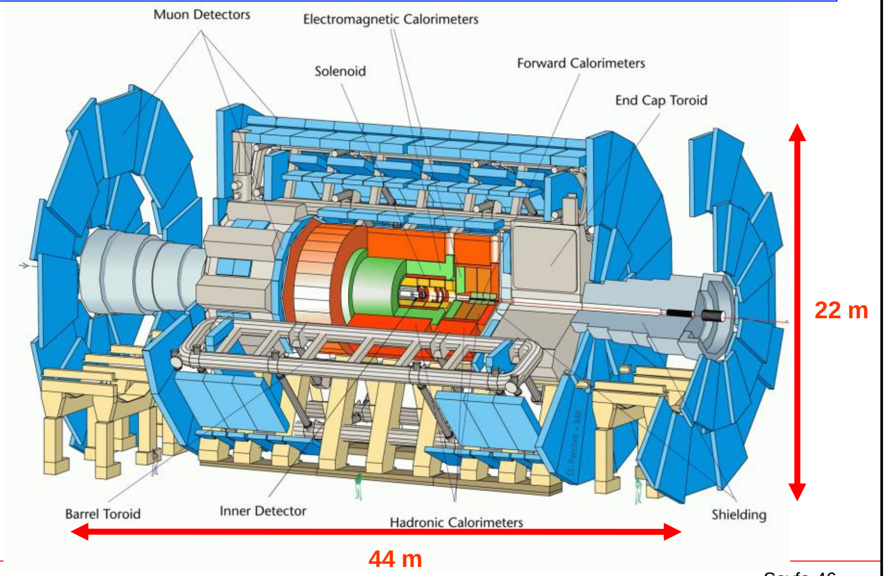


Technology

LHC

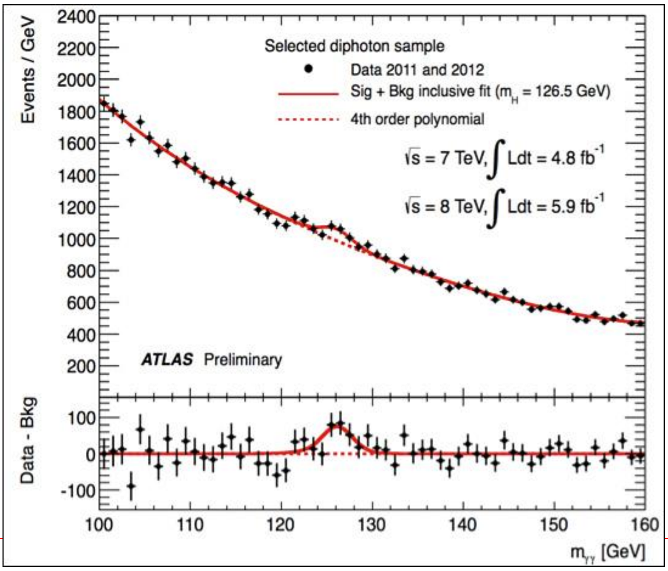
Particle Detectors

ATLAS Detector: 34 countary / 175 University



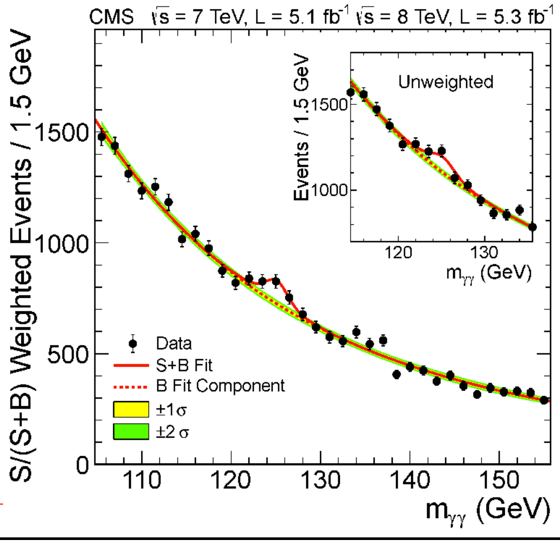
Discovery of the Higgs ?

July 2012, *ATLAS* data ($H \to \gamma\gamma$)



Discovery of the Higgs ?

July 2012, *CMS* data ($H \to \gamma\gamma$)



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