The First Engineering Specialties

Five early fields of engineering emerged to meet the growing needs of society that were brought about by the industrial revolution in the 1800s. These engineering fields were civil, mining and metallurgical, mechanical, chemical, and electrical.

Civil Engineering. Civil engineers meet society's needs for infrastructure—things like roads, railways, bridges, dams, water supply systems, and sewage systems. A critical part of designing these structures is making sure they will stay where they are put—that they will not tilt, shift, or sink into the soil over time. Therefore, civil engineers often apply knowledge of geology and physics in their work.

Mining and Metallurgical Engineering. Mining and metallurgical engineers work to make mining and refining metals more predictable, safer, and less expensive. They do this by applying the principles of materials science—the study of the properties and behavior of solids, liquids, and gases.

Metallurgical engineers have advanced the ore refining processes by creating new mixtures (alloys) tailored to meet specific needs. Examples are hard metals that can hold a sharp edge, soft metals that can be stamped with artistic patterns, noncorrosive and weather-resistant metals, and metals that can withstand very high or very low temperatures. The metallurgist strives to meet the project's goals by delivering alloys with just the right properties in such areas as cost-effectiveness, weight, durability, and strength.

Mechanical Engineering

Mechanical engineers apply the principles of physics to design, build, and maintain mechanical systems. That can mean anything from designing a collapsible cardboard box for holding doughnuts to constructing the most advanced jet engines.

Some mechanical engineers specialize in converting energy into more useful forms. Boilers and generators convert heat to electricity in coal-fired, gas-fired, and nuclear power plants. The energy in falling water can be used to generate electricity. Heat from the sun can be collected and used to heat water or even generate electricity.

Many mechanical engineers specialize in moving heat to where it is wanted and away from where it is not wanted. They design boilers, gasoline engines, and gas turbines (jet engines) that can operate for long periods without overheating, or fans to cool the microprocessors in computers.

Other mechanical engineers take the converted energy and devise machines to do useful things with it: Automobiles, lawn mowers, microengineered medical equipment, aircraft landing gears, and machines to mold plastic toys or fill soda bottles are all examples. These engineers learn how to use shafts and bearings, pulleys, gears, and mechanisms (collections of levers) to make things move around or back and forth or in special patterns, at specified speeds.

Chemical Engineering. Chemical engineers develop useful things based on the newest advances in chemistry. In the process, they harness their knowledge of chemicals, chemical reactions, and raw materials. When chemists create a new medicine, plastic, fiber, fabric, or glue, they normally make only a small amount in the laboratory. Chemical engineers devise ways to adapt these small laboratory experiments into full-scale productions in processing plants that can efficiently make tons of the new substance every day.

Electrical Engineering. Electrical engineers discover how to harness electricity to do more for people. They study and apply electronics and electro-magnetism (the physics of electricity and magnetism).

Electrical engineering had its start during the latter part of the 19th century. The original focus was on generating and distributing electricity widely, to replace steam and water as sources of power and gas as a fuel for lighting. Along the way came inventions like electrically powered trains, microwave ovens, and other modern conveniences that have dramatically changed our lives, as well as communication devices that have brought people around the world closer together.

Electrical communications started with the telegraph before the Civil War, followed by the telephone (1876) and the radio (late 1800s). Television was first demonstrated in the United States in 1927. The transistor was invented in the late 1940s and showed up in portable radios by the late 1950s. Some of the earliest electronic computers were developed during World War II. The first modern digital computer, the ENIAC, was a giant machine that used vacuum tubes. The integrated circuits that make possible desktop computers were invented in the late 1950s, followed by the microprocessor and the first personal computers in the 1970s.

The specialties of modern electrical engineering include:

- Power generation and distribution
- Electrical machinery (motors and things run by motors)
- Communications (telephones, radio, TV, and data)
- Computer systems, sometimes called information systems
- Control systems (like those that guide robots)
- Electronic devices (integrated circuits, microprocessors)

Today's Many Fields of Engineering

As technologies have become more complex and the products based on them more complicated, more modern engineering specialties have developed.

Aerospace Engineering. Aerospace engineers are specialized mechanical engineers that study the way airplanes and rockets interact with the air to fly; develop lightweight structures for airplanes and space vehicles; and design the high-powered engines needed to propel airplanes and lift space vehicles clear of Earth's gravity and atmosphere. Aerospace engineers specializing in aerodynamics design specially shaped wings, tails, and airplane bodies to move through the air with the least possible resistance.

Agricultural Engineering. Agricultural engineers design farm and food-processing equipment and develop systems for irrigation, drainage, and waste disposal. Some experiment with new ways to grow crops more efficiently, like hydroponics (growing plants without soil).

Architectural Engineering. Architectural engineers work with architects on the systems that make buildings functional, such as elevators and escalators, heating and cooling systems, and ventilation and air-conditioning systems. They also work with earth scientists to understand when, how, and at what strength natural forces—such as wind, rain, and earthquakes—will affect buildings.

Bioengineering. Bioengineering combines biology and engineering and also relies on the principles of biomechanics—the study of the mechanics (or workings) of living organisms. Bioengineers work with medical doctors to design surgical instruments, artificial organs like heart valves and hearts, implants to replace weakened bones, and prosthetics like artificial legs to help people who have been hurt in accidents.

Ceramic Engineering. Ceramic engineers work with processes that convert clay and nonmetallic minerals into ceramic products such as dishes, protective tiles for the space shuttle, and solar panels. During production, ceramic products are heated in very hot ovens, making them among the best materials for parts that will be exposed to high heat—such as inside a jet engine, or on the surface of a spaceship that must fly through the atmosphere to return to Earth.

Computer Engineering. The amazing rate at which computers have progressed is due in large part to computer engineers, who continue to find ways to make memory storage devices smaller, to fit more circuits on a microchip, and to move data faster and faster through the circuits. Devices for holding data and software programs, as well as media files such as photographs and movies, have exploded in capacity while their physical size has gotten smaller. The computer that controlled the lunar lander when Apollo astronauts landed on the moon in 1969 cost more than a million dollars. Today, the cheapest home computer has far more power than the Apollo computer—and costs a fraction of the price.

Environmental Engineering. Environmental engineers study the quality of the air, water, and land and develop systems to reduce pollution and help restore Earth to good health. Increasingly complex computer programs now allow environmental engineers to create computer models of the movement of air and pollutants. This lets engineers pinpoint the worst sources of pollution and how to improve air quality for the entire area. Once environmental engineers identify which polluting chemicals are coming out of the exhaust stack of a particular factory, for instance, they can design special equipment to clean up the exhaust and improve the air quality around that factory.

Industrial Engineering. Industrial engineers are concerned with how manufacturing plants are organized: what machinery there is, how materials and the things being made flow through the factory, and how people are organized to make the factory as effective as it can be. They often are involved in managing warehouse operations such as tracking inventory, routing conveyors, and overseeing materials handling. They use the branch of mathematics called statistics to design efficient systems.

Manufacturing Engineering. Mass-producing large quantities of products requires special knowledge of high-speed machinery (including automated machines and robots) to make sure the parts and finished products really are identical. This is the task of manufacturing engineers. They understand how machine tools cut metal, how tools wear out, and how assembly robots can consistently make good products day after day.

Marine or Naval Engineering. Just as special skills are needed to create vehicles that move through the air, designing ships also requires unique knowledge and mathematical tools. Marine or naval engineers design equipment for a structure that is constantly moving, twisting, and being slammed by environmental factors such as weather, salt water, current, and marine life.

Ocean Engineering. Some engineers say it is harder to work in the ocean than in outer space. Oceanic pressures are extremely high, temperatures vary greatly, unusual materials are found, and the wildlife ranges from Earth's tiniest animals to the largest known mammal. Ocean engineers design ways to harvest food from the ocean or harness the energy in waves. Some engineers are developing new methods and machines to make it possible to work and live beneath the sea for long periods.

Petroleum Engineering. Petroleum engineers are specialized chemical engineers who develop efficient ways to extract crude petroleum from the ground. Near the coast of Southern California, oil-drilling rigs on the land actually branch out under the sea to find oil deposits. It is difficult and complex to drill more than a mile straight down into the earth. Can you imagine the extra engineering problems of drilling sideways?

Software Engineering. Software engineers apply the findings of computer science to design complex software systems and products—from the systems that control airplanes in flight, to the systems that watch over our money in banks, to exciting new computer games. They learn or create different programming languages to do different kinds of tasks. The fast-moving graphics action of a computer game is quite different from carrying out a detailed mathematical analysis. Creating photographlike images, complete with shadows and reflections, is different from searching a huge database for related items of information.

Systems Engineering. Complex systems like an airplane or a power plant require the expertise of many kinds of engineers. Systems engineers figure out how all the many parts of a complex system work together, so that a plane will fly safely or a power plant will generate power steadily, safely, and cleanly. Systems engineers often are the first engineers on a new project. They translate the customer's needs (like high-quality surround sound for a home-theater system) into requirements and specifications that other engineers can follow as they design the product. They then design tests to ensure that the finished product actually does what it was designed to do.

Besides the fields described above, there are other, more highly specialized fields of engineering. Engineers must be able to work in teams because many problems or projects are highly complex. Several specialties may be required to complete the project, and no one engineer may have all the necessary knowledge.