

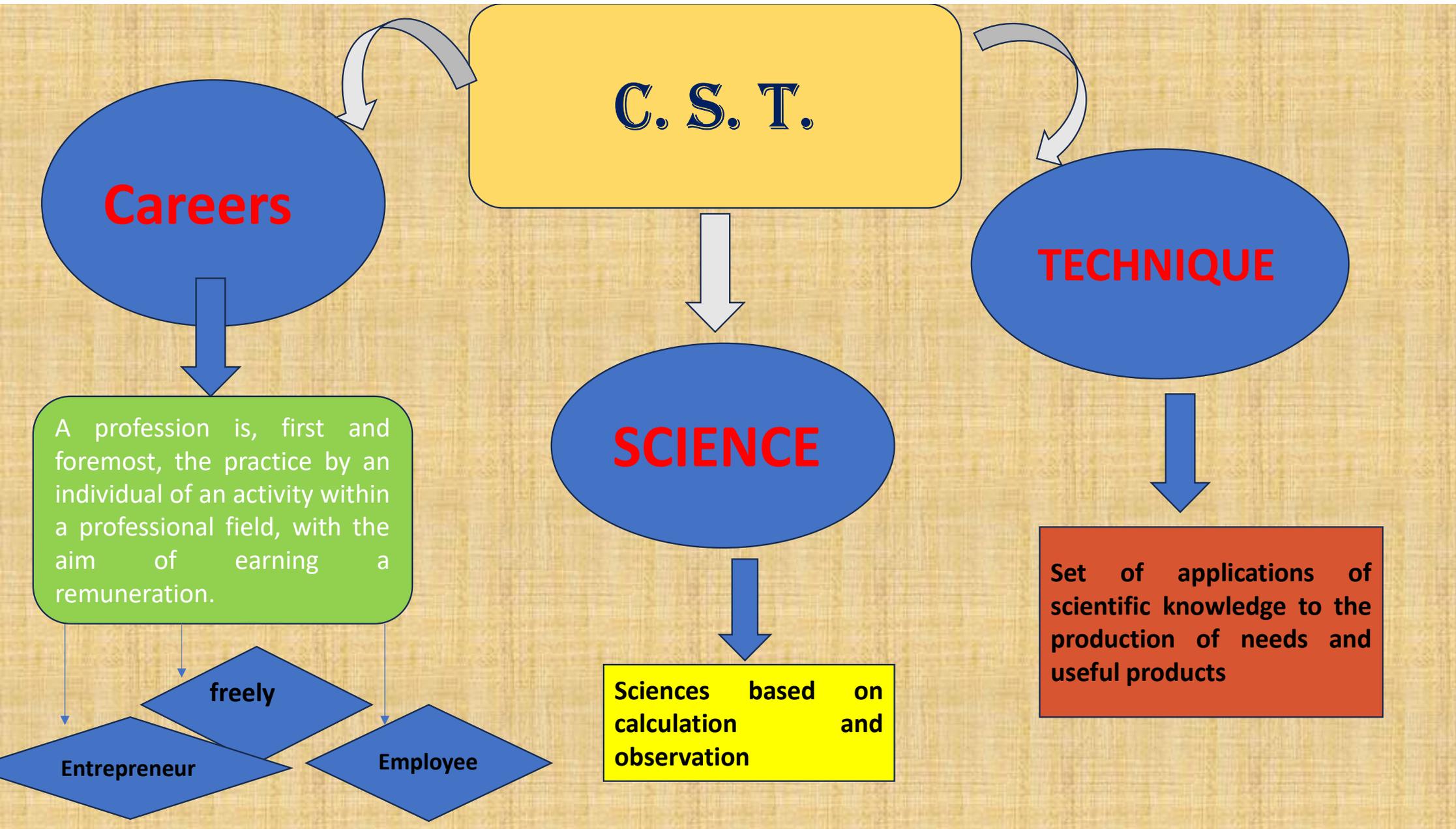


Careers in Science and Technology



Université Abou-Bakr Belkaid
Tlemcen

Dr I. SARI-ALI



- *Chapter I: The Engineer*
- *Chapter II: Careers in Electronics, Telecommunications, Biomedical Engineering, Electrical Engineering, Electromechanics, Optics, and Precision Mechanics*
- *Chapter III: Careers in Automation for Industrial Engineering*
- *Chapter IV: Careers in Process Engineering*
- *Chapter V: Sustainable Development*
- *Chapter VI: Careers in Sustainable Development Engineering*

OBJECTIVE

- The objective of this course is to enable first-year Science and Technology students to explore the wide range of careers related to science and technology, to understand the skills and educational pathways required to access them, and to reflect on their own professional orientation. Through concrete examples, testimonials, and activities, students will gain a better understanding of the current challenges in these fields and identify the career opportunities available to them.

Career

- **1. Occupation that provides a livelihood**
- *The engineering profession*
- *This actor is experienced / This actor has skill*
- *A man of the trade: a teacher, a specialist...*
- **2. Each of the business sectors of a company or an industrial group**
- *Business sector / Field of activity*
- **3. Machine used for fabric production**
- *Weaving loom*
- *Embroidery machine*

SCIENCE

- **1. Knowledge that one has of something**
- *The science of good and evil*
- *It is said: This man is a fountain of knowledge*
- **2. Sciences based on calculation and observation**
- *Mathematics – Physics – Chemistry – etc.*
- *Also called exact sciences or hard sciences*
- **3. Human sciences**
- *Those that take human beings as their subject*
- **4. Natural sciences**
- *Which study nature and its laws*
- **5. Pure sciences**
- *Whose purpose is fundamental knowledge, as opposed to applied sciences*

TECHNIQUE

- **1.** The set of applications of scientific knowledge to the production of needs and utilitarian products.
- **2.** A specific process used to successfully carry out a concrete operation, to manufacture a material object, or to adapt it to its function.
- **3.** The collection of methods and procedures implemented in the practice of an activity.
- *The technique of silk painting*
- *The technique of vehicle inspection*

• TECHNOLOGY

The study of industrial techniques considered as a whole or within a specific field of activity.

• Knowledge

It is the set of general or specialized knowledge required to carry out an activity. This may include theoretical knowledge, technical expertise, or tools necessary for solving a given problem.

Example: academic knowledge, language proficiency, computer skills, etc.

Knowledge answers the question: *“I know, I have learned, I am familiar with...”*

Careers by Sector

- Each sector of activity brings together different professions.
- *It would take a great deal of time to describe them all.*
- *We will therefore focus only on those that require specific training.*

IN SCIENCE AND TECHNOLOGY



THIS IS THE PURPOSE OF THIS COURSE

Some examples of professions

- Professor
 - • Scientific Researcher
 - • Teacher
 - • Engineer-Architect
 - • Pharmacist – Doctor
 - • Laboratory Technician
 - • Magistrate – Military
 - • Journalist
 - • Pilot – Chauffeur
 - • Accountant
 - • Translator
 - • Administrator
 - • Actor – Musician
- Farmer – Fisherman
 - Hotelier
 - Baker – Pastry Chef
 - Mechanic – Electrician
 - Heating Engineer – Plumber
 - Mason – Painter – Carpenter
 - Tailor
 - Firefighter
 - Postman
 - Garbage Collector
 - Athlete (Football, Boxing, etc.)



CHAPTER I

THE ENGINEER



Among all the professions that require a university education in the field of science and technology, the profession of engineer remains the most relevant, as it is found in almost all sectors of activity and covers a wide range of specializations such as mechanics, hydraulics, agronomy, electronics, electrical engineering, telecommunications, computer science, civil engineering, architecture, and more.

Introduction to the engineering profession

- 1. The **engineering** profession is a constantly evolving one that requires skills, intuition, methodology, and a strong ability to adapt.
- 2. An **engineer** can perform several functions, such as:
 - – design
 - – production
 - – operation
 - – maintenance
 - – distribution
 - – technical sales or after-sales service of equipment, products, processes, logical systems, or services with a predominantly technical focus

3. The engineer participates in research on science and technology

4. The engineer is employed by industrial or service companies, public, semi-public, private organizations, communities or the State.

5. Also, he can create his own company

6. After experience, he can also occupy a management position, in all fields of activity.

7. While respecting the minimum standards set for him, the engineer aims to optimize the result of his mission, in the areas of safety, environmental protection, quality, economic and financial cost, convenience of maintenance, ease and pleasure of use, compliance with deadlines agreed within the framework of activities relating to the engineering profession.

8. A consulting engineer is a professional who gives advice, draws up projects, monitors work, attends expert assessments

- **What does the engineering profession consist of?**
- Solving technical problems.
- Designing and improving products, systems, or processes.
- Managing projects, teams, and budgets.
- Listening to the needs of clients and users.
- Innovating in fields such as industry, digital technology, environment, etc.

- **Qualities and skills required**

- Logical mindset, rigor, and autonomy.
- Creativity and scientific curiosity.
- Ability to work in a team and communicate effectively.
- Proficiency in computer tools and specialized software.
- Sense of responsibility and project management skills.

- **Fields of Activity of Engineers**

There is a wide variety of engineers depending on the field of activity. Below are a few examples.

- **1. Civil Works Engineer**

- **Definition:** The civil works engineer designs, plans, and supervises the construction of infrastructures such as roads, bridges, tunnels, dams, or water supply networks.
- **Missions:** Site studies, project management, team coordination, compliance with safety standards.
- **Sectors:** Construction, land development, local authorities.

- **2. Civil Engineer**

- **Definition:** A civil engineer designs and oversees the construction of buildings (houses, apartment complexes, hospitals) as well as complex structures (viaducts, stadiums, power plants).
- **Missions:** Structural calculations, selection of materials, technical plans, site supervision.
- **Difference from Public Works Engineering:** Civil engineering is broader and also includes buildings, not only public infrastructures.

- **3. Methods Engineer**

- **Definition:** The methods engineer improves production organization by optimizing technical and human resources in factories.
- **Missions:** Analysis of manufacturing processes, continuous improvement, drafting of procedures, saving time and reducing costs.
- **Sectors:** Automotive industry, aeronautics, agri-food, mechanical engineering.

- **4. Design Office Engineer**

- **Definition:** Works upstream of projects to design plans and technical solutions for a product or a structure.

- **Missions:** 3D modeling, calculations, virtual testing, compliance with technical constraints.

- **Sectors:** Engineering, construction, industrial design.

- **5. Quality Engineer**

- **Definition:** Ensures that products, services, and processes comply with quality, safety, and environmental standards.

- **Missions:** Audits, quality control, implementation of ISO standards, staff training.

- **Sectors:** All industries (automotive, pharmaceutical, electronics, etc.).

- **6. Automation Engineer**

- **Definition:** A specialist in automated systems, who designs machines capable of operating without human intervention.

- **Missions:** Programming of PLCs (Programmable Logic Controllers), creation of robotic systems, maintenance.

- **Sectors:** Industrial production, robotics, home automation.

- **7. Mechanical Engineer / Electronics Engineer**

- **Mechanical Engineer**

- **Definition:** Designs and develops parts, mechanisms, and machines (engines, turbines, vehicles, etc.).

- **Missions:** Computer-Aided Design (CAD), testing, prototyping.

- **Electronics Engineer**

- **Definition:** Designs electronic systems (circuits, sensors, electronic boards).

- **Missions:** Assembly, programming of components, maintenance.

- **8. Computer Engineer**

- **Definition:** Designs, develops, and tests software, systems, or computer applications.

- **Missions:** Coding, cybersecurity, database management, AI, cloud computing.

- **Specializations:** Software developer, network engineer, data scientist, cybersecurity expert.

- **9. Business Engineer**

- **Definition:** An engineer with strong commercial skills who sells complex technical projects while ensuring the link between clients and technical teams.

- **Missions:** Drafting proposals, negotiating contracts, project follow-up.

- **Key Skill:** Project management and customer relations.

- **10. Sales Engineer**

- **Definition:** Sells technical products or services while advising clients on suitable solutions.
- **Missions:** Prospecting, technical demonstrations, after-sales support.
- **Hybrid Profile:** Technician + salesperson.

CHAPTER II

CAREERS IN ELECTRONICS, TELECOMMUNICATIONS, BIOMEDICAL ENGINEERING, ELECTRICAL ENGINEERING, ELECTROMECHANICS, OPTICS, AND MECHANICS



- **1. Preamble**

Technological development in the fields of electronics, telecommunications, biomedicine, and precision mechanical systems has profoundly transformed our daily lives. These sectors lie at the crossroads of physical sciences, engineering, and computer science.

- Professionals working in these fields design connected devices, advanced medical equipment, communication networks, and embedded systems for vehicles or satellites. These careers require rigor, innovation, and mastery of advanced technological tools.

2. What is **Electronics**?

2.1 Definition



Electronics is the science that studies and utilizes electrical phenomena to process, store, and transmit information. It is based on the behavior of electrons in components and circuits to create useful functions such as sound amplification, image display, digital computation, and more. It forms the foundation of almost all modern devices: smartphones, computers, cars, medical equipment, televisions, and many others.

- **2 What is an Electronic Component?**

- An **electronic component** is a **basic unit** used in circuits to perform specific electrical functions, such as resistance, signal filtering, amplification, or switching.

- **3 Common types of components include:**

- **Resistor:** Limits the flow of electric current.
- **Capacitor:** Stores and releases electrical energy.
- **Diode:** Allows current to flow in only one direction.
- **Transistor:** Amplifies or switches electrical signals.
- **Integrated Circuit (IC):** A microchip that contains multiple components performing complex tasks.
- These elements are assembled on printed circuit boards (PCBs) to form electronic systems.



- **.4 Subfields of Electronics**

- Electronics encompasses several specialized areas, such as:
- **Analog electronics:** Focused on continuous signal processing (e.g., audio, radio).
- **Digital electronics:** Involves binary data processing and logic circuits.
- **Power electronics:** Controls high-voltage/current devices (e.g., motor drives, converters).
- **Microelectronics:** Concerned with the design of miniaturized components (e.g., microchips).
- **Embedded systems:** Integrates electronics into non-computer systems (e.g., in cars, robots).
- **Radiofrequency (RF) electronics:** Specializes in wireless communication.
- **Nanoelectronics:** Deals with devices on the nanometer scale, critical to modern computing.

• **5 What Are the Responsibilities of an Electronics Engineer?**

- An electronics engineer is responsible for:
- Designing and developing electronic circuits and systems,
- Simulating and testing components,
- Programming microcontrollers and embedded systems,
- Integrating electronics into complex products,
- Ensuring system performance, reliability, and compliance,
- Collaborating with cross-functional teams (software, mechanical, etc.).

- **6 What Skills Are Required?**

- Key skills and knowledge expected of an electronics engineer include:
- Strong foundation in physics and circuit theory,
- Proficiency with **CAD tools** (e.g., KiCad, Altium),
- Programming capabilities (e.g., C, Python, VHDL),
- Experience with lab instruments (oscilloscopes, multimeters, signal generators),
- Analytical thinking, attention to detail, teamwork, and adaptability.

.3 Becoming a Telecommunications and Network Engineer

- **3.1 What Does a Telecommunications and Network Engineer Do?**
- This engineer specializes in **designing, implementing, and maintaining communication systems** that allow data, voice, and multimedia to be transmitted across distances.
- Responsibilities include:
 - Setting up and configuring communication networks (LAN, WAN, mobile),
 - Ensuring data transmission quality and security,
 - Working with equipment such as routers, antennas, and fiber-optic systems,
 - Supporting the deployment of technologies like 5G, IoT, and cloud computing.

- **3.2 Skills and Qualities Required for This Career**

- Strong knowledge of **network protocols** (TCP/IP, DNS, VPN),
- Understanding of wireless communication standards (Wi-Fi, 4G/5G, Bluetooth),
- Familiarity with **cybersecurity and virtualization tools**,
- Ability to diagnose and solve connectivity issues,
- Good communication and project management skills.



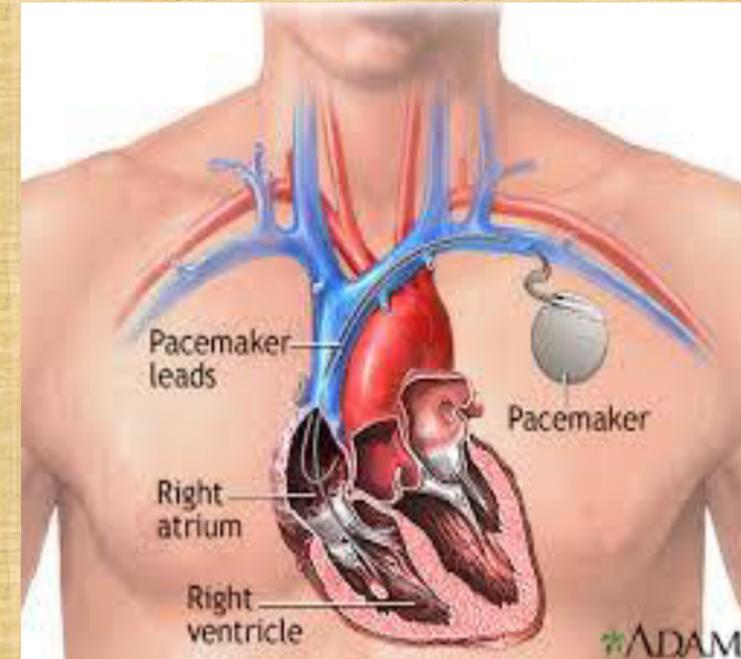
- **3.3 Career Path and Opportunities for Growth**

- Entry-level positions may include:
 - Network Administrator,
 - Telecommunications Technician,
 - System and Network Engineer.
- **Career advancement** may lead to:
 - Network Architect,
 - Cybersecurity Manager,
 - Project Leader in Telecom Deployment,
 - Digital Transformation Consultant.
- Engineers in this domain are highly sought after in sectors such as IT, defense, energy, transportation, and mobile operators.

4. Biomedical Engineer

4.1 Définition

A biomedical engineer is a professional who applies principles from engineering, biology, and medicine to design and optimize medical devices, health systems, and diagnostic tools. Their objective is to **improve patient care and advance medical technology.**



- **4.2 What Does This Job Involve?**

- The biomedical engineering profession involves **bridging the gap between medicine and technology**. Biomedical engineers work on the design, development, testing, and maintenance of medical equipment and systems. They often collaborate with physicians, surgeons, and healthcare providers to identify technological solutions that meet clinical needs.

• **2.4.3 Tasks of a Biomedical Engineer**

Key responsibilities include:

- Designing and optimizing medical devices (e.g., imaging systems, prosthetics, surgical tools),
- Conducting tests and validations to ensure safety and effectiveness,
- Maintaining and repairing medical equipment in healthcare facilities,
- Ensuring compliance with health and safety regulations,
- Participating in clinical trials or research on new biomedical technologies,
- Training medical personnel on the use of technical equipment.



- **4.4 Employment Sectors**

- Biomedical engineers can work in various sectors, including:
- **Hospitals and health institutions** (equipment maintenance and integration),
- **Medical device manufacturers** (design, production, and quality control),
- **Research and development laboratories,**
- **Public health agencies and regulatory bodies,**
- **Academic and training institutions** (as researchers or educators).

• **4.5 Career Development**

A biomedical engineer may evolve toward roles such as:

- **Project Manager** for medical technology innovation,
- **Research Scientist** in applied health technology,
- **Regulatory Affairs Specialist** (ensuring compliance with medical standards),
- **Clinical Engineer** supporting hospitals and care services,
- **Entrepreneur or consultant** in health-tech start-ups.

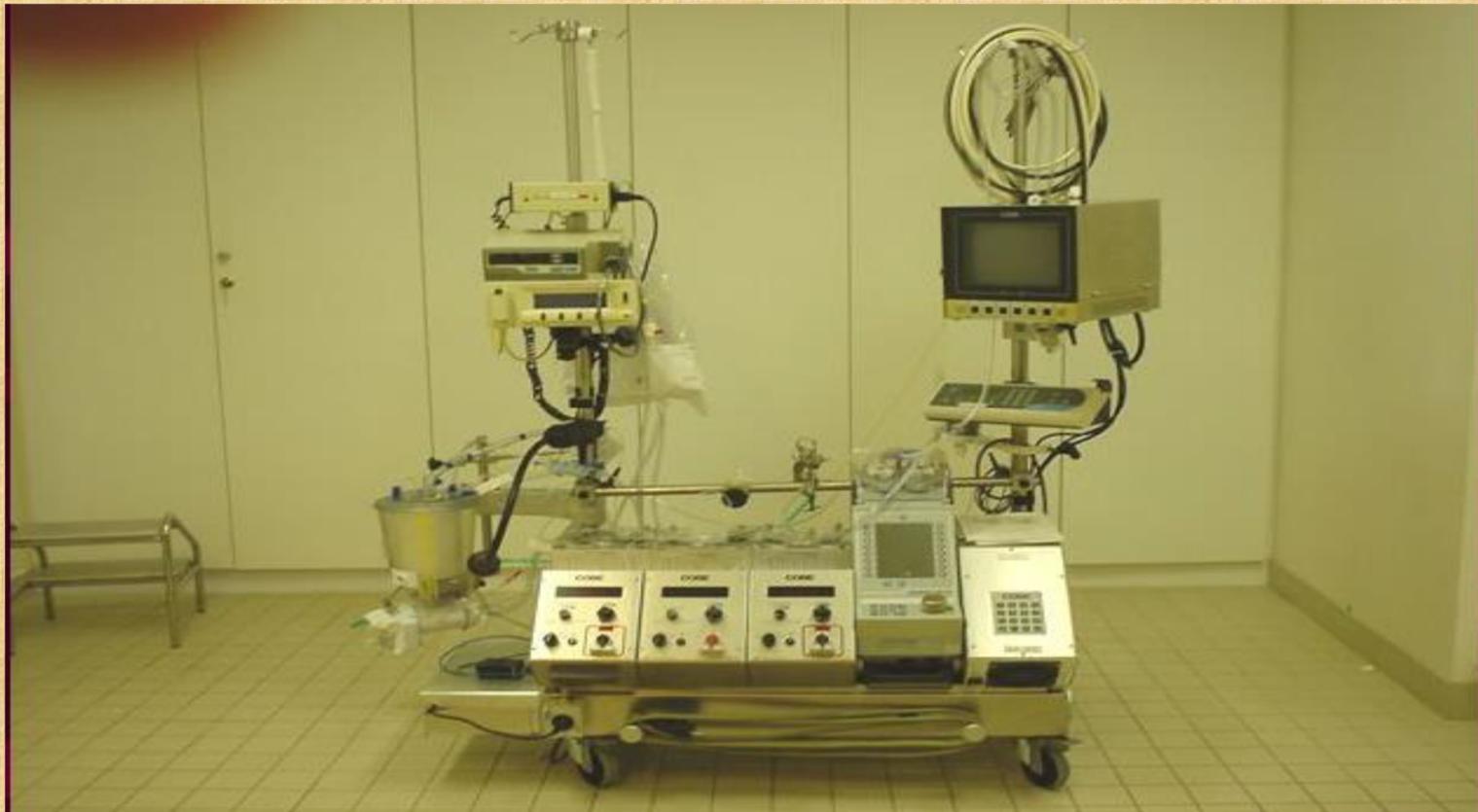
With experience and specialization, they may take on strategic roles in innovation, technical leadership, or company management within the healthcare and biomedical industry.

Here are some examples of biomedical devices and equipment designed for treatment and diagnosis:

- Artificial respirators
- Heart monitors
- Defibrillator monitors



Extracorporeal circulation devices for heart surgery

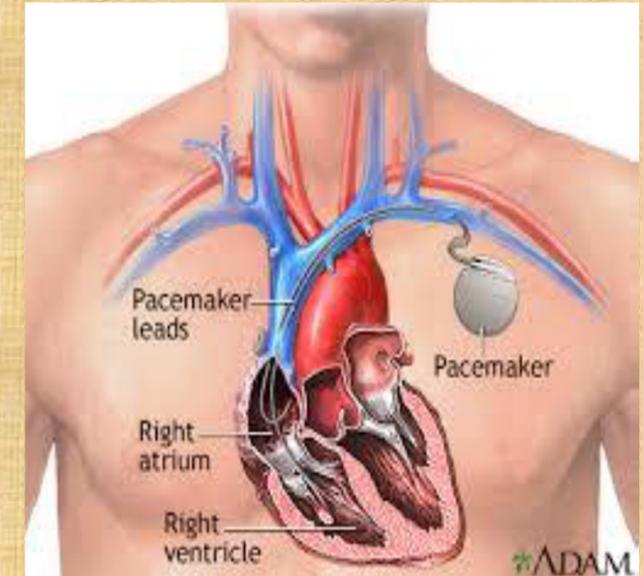
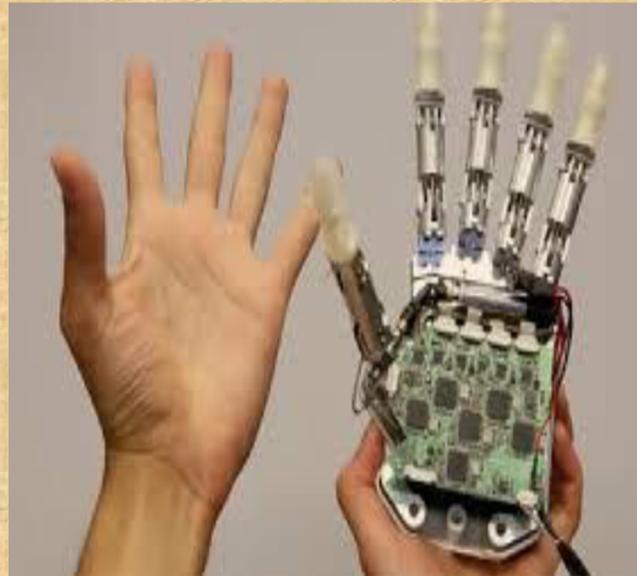


Medical imaging systems (including ultrasound scanners, electroencephalographs, scanners, MRI)



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Prosthetics, pacemakers



Other medical electronic devices



Cancer Treatment Devices



Microsurgery and computer-assisted surgery devices

Clinical laboratory analyzers



5 Electrical Engineer

5.1 Définition

An electrical engineer is a specialist in electrical systems. They design, develop, install, and maintain equipment powered by electricity, in fields such as industry, transportation, energy, and construction. Their work focuses on the **generation, distribution, and optimization of electrical energy**, while ensuring safety, efficiency, and compliance with standards.



5.2 What Training Is Required to Become an Electrical Engineer?

- Several academic paths can lead to this profession:
- **Preparatory scientific classes** followed by an engineering school (e.g., INSA, Arts et Métiers, Polytech),
- **Bachelor's degree in engineering sciences** with a focus on electrical or power engineering,
- **Engineering diploma** from a specialized institution in electricity or automation,
- **Professional Master's programs** in renewable energy, smart grids, or industrial automation.

Typical coursework includes:

- General and industrial electricity,
- Electric machines (motors, transformers),
- Power electronics,
- Automation and embedded systems,
- Simulation software (e.g., Matlab/Simulink, Eplan, LabVIEW).

• **5.3 What Is the Average Salary of an Electrical Engineer?**

The salary varies based on experience, industry, and location. On average:

- **Entry level:** between **€2,500 and €3,000 gross/month**,
- **Mid-career (5–10 years):** between **€3,500 and €4,500 gross/month**,
- **Senior or project manager:** up to **€5,500 gross/month**, sometimes more in specialized sectors (energy, aerospace, rail).



• **5.4 Related Professions**

Several jobs are closely related to electrical engineering, including:

- **Electrotechnical technician,**
- **Energy engineer** (especially in renewable energy),
- **Automation and control systems engineer,**
- **Industrial maintenance engineer,**
- **Electrical project manager,**
- **Embedded electrical systems designer**

6-Electromechanical Engineer

• 6.1 Tasks of an Electromechanical Engineer

The electromechanical engineer designs, develops, and maintains systems that combine **electrical, electronic, and mechanical components**. Their work is crucial in the production of machines, automated industrial equipment, motors, and robotics.

Typical responsibilities include:

- Designing electromechanical systems (e.g., elevators, production lines, engines),
- Integrating electrical and mechanical components into complex systems,
- Developing automation solutions for industrial processes,
- Supervising installation, testing, and commissioning of equipment,
- Diagnosing and resolving technical malfunctions,
- Writing technical documentation and intervention reports.



• 6.3 Employment Sectors

Electromechanical engineers are in demand across a wide range of industries:

- **Manufacturing** (automotive, metallurgy, food processing),
- **Energy and electricity generation** (power plants, distribution networks),
- **Industrial robotics and automation,**
- **Rail and aerospace transportation,**
- **Industrial maintenance and production engineering.**
- They may advance into roles such as **project manager, maintenance supervisor, technical consultant, or mechatronics systems expert.**



Optical Engineer



An optical engineer is a specialist who designs, develops, and optimizes systems and devices that use light (optics and photonics). This profession lies at the interface of physics, engineering, and sometimes computer science.

Main responsibilities:

- **Design of optical systems:** lenses, mirrors, lasers, optical fibers, sensors, and measuring instruments.
- **Development and modeling:** use of simulation software (e.g., Zemax, Code V, COMSOL) to design suitable devices.
- **Experimental characterization:** testing and measuring optical performance (resolution, transmission, losses, aberrations).
- **Industrial integration:** adapting optical solutions to complex systems (cameras, medical instruments, satellites, telecommunication systems).
- **Innovation:** research on new optical materials (metamaterials, nonlinear crystals, photonic nanostructures).

Application Fields:

- **Healthcare:** medical imaging, endoscopy, ophthalmology (lasers for eye surgery).
- **Telecommunications:** optical fibers, high-speed data transmission.
- **Aerospace & Defense:** vision systems, telemetry, satellite imaging.
- **Energy:** advanced photovoltaic cells, solar sensors.
- **Industry:** quality control through optical inspection, lasers for cutting and welding.

Working Conditions:

The working conditions of an optical engineer depend on the sector:

- In **research laboratories** (public or private), they may spend a significant amount of time on experimentation or simulation.
- In **design or R&D offices**, the work is mainly technical, involving regular collaboration within project teams.
- In **industry**, they may be involved in production or quality control, often facing constraints of deadlines and precision.
- Working hours are generally regular, but can be adjusted depending on the critical phases of a project.

- **Required Skills:**

An optical engineer should possess the following competencies:

- Strong foundations in optics and photonics physics.
- Proficiency in optical CAD software for design and simulation.
- Skills in applied mathematics, signal processing, control systems, and electronics.
- Ability to work within multidisciplinary teams.
- Scientific rigor, curiosity, and creativity.

8- Mechanical Engineer



• 8.1 Mechanical Engineer Tasks

A mechanical engineer specializes in the **design, analysis, manufacturing, and maintenance** of mechanical systems. Their work applies to machines, engines, structures, production systems, and mechanical components across various industries.

Main responsibilities include:

- Designing mechanical parts and assemblies using CAD software (e.g., SolidWorks, CATIA, Inventor),
- Performing mechanical calculations (forces, stress, material resistance),
- Contributing to product industrialization,
- Optimizing system performance, energy efficiency, and reliability,
- Ensuring compliance with quality standards and technical specifications,
- Monitoring technological developments and proposing innovative solutions.

- **8.2 Key Qualities for the Position**

- Success in this role requires:

- Strong understanding of mechanics, thermodynamics, materials science, and mechanical systems,

- Skills in industrial drawing, 3D modeling, and numerical simulation,

- Analytical thinking, precision, and attention to detail,

- Interest in technology and solving practical problems,

- Good communication and teamwork abilities,

- Familiarity with ISO standards and quality tools (FMEA, Six Sigma, etc.).

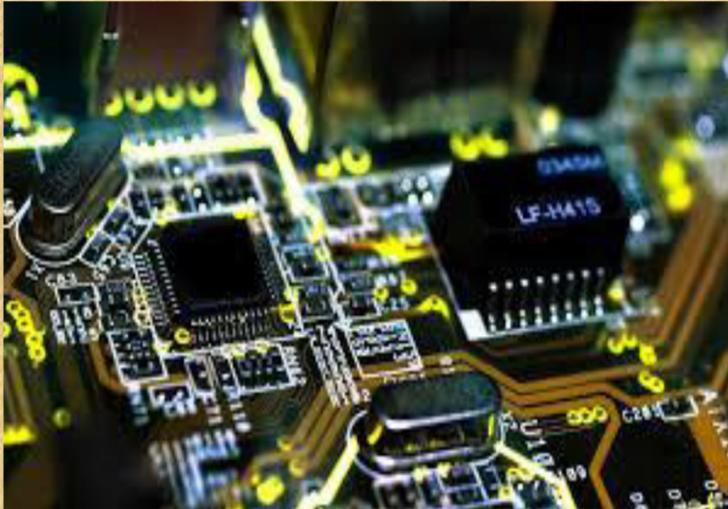
• **8.3 Career Opportunities**

Mechanical engineers are in demand in sectors such as:

- **Automotive, aerospace, and rail industries,**
- **Energy (nuclear, wind, oil & gas),**
- **Precision mechanics and industrial equipment,**
- **Engineering consultancies and design offices,**
- **Industrial maintenance and manufacturing.**
- Career development paths include **project manager, design office manager, R&D engineer, or technical director.**

CHAPTER III

CAREERS IN AUTOMATION WITHIN INDUSTRIAL ENGINEERING





- **What is Automation?**

Automation refers to the set of scientific methods and technological means used to design systems capable of operating without human intervention during their normal functioning phase.

Professionals working in this field are called *automation engineers* (or *control engineers*).

The devices designed to enable the automation of a system (e.g., controllers, regulators, programmable logic controllers) are referred to as *automatisms* or *control-command units* of a controlled system.

- **Preamble**

Automation is a key branch of industrial engineering focused on designing, analyzing, and controlling automated systems. It is applied across a wide range of domains such as industrial production, robotics, home automation, transportation, and intelligent systems.

Indeed, automating a production system provides several advantages compared to a non-automated system (such as traditional craftsmanship).

Automation allows:

- **Consistency in manufactured products:** each item is identical to the previous one.
- **Improved quality:** ensured by the uniformity of production.
- **Reduced lead times:** each step of the manufacturing process is carried out more quickly and with consistent timing, thus shortening the overall production cycle.
- **Lower costs:** particularly through economies of scale, as automation enables higher output.
- **Enhanced safety:** by reducing occupational risks associated with manufacturing processes that may be hazardous to humans.

History of Automation

The history of automated systems can be divided into three major periods:

- **First period (from Antiquity to the mid-19th century):**
Early mechanical devices and rudimentary automata were developed, often driven by water, wind, or simple mechanical systems. Examples include hydraulic machines and clockwork mechanisms.
- **Second period (19th to 20th century):**
The Industrial Revolution marked the rise of mechanization, steam engines, and the first control devices, laying the foundation for industrial automation.
- **Third period (from the 1950s onward):**
The emergence of electronics, computing, and programmable logic controllers (PLCs) enabled modern automation, integrating sensors, actuators, and control systems to create highly efficient and intelligent production processes.

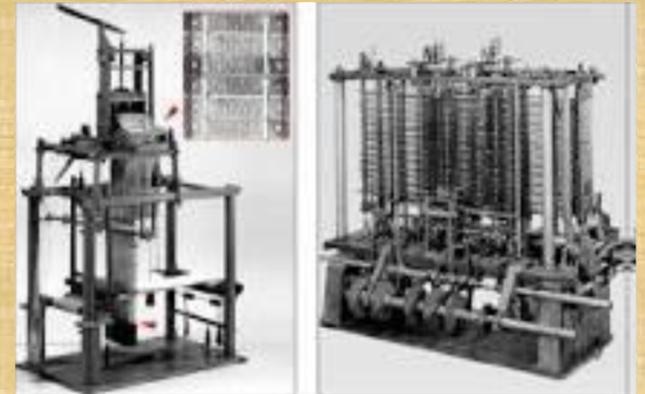
First Period (from Antiquity to the mid-19th century)

- The *clepsydra* (a water clock) was invented by a Greek mechanic named Ctesibius in Alexandria (Egypt) in the 3rd century BC.
- At the end of the 3rd century BC, the Greek engineer Philo of Byzantium used a principle similar to that of the clepsydra to design a constant-level oil lamp.
- The 1st century AD was marked by the invention of an automatic door system by the Greek engineer Hero of Alexandria.
- Several centuries later, in 1642, the French physicist Blaise Pascal invented the first calculating machine, known as the *Pascaline*.



- **First Period (from Antiquity to the mid-19th century) – Continuation**

- In 1788, the Scottish engineer James Watt invented the flyball governor, designed to maintain the rotational speed of a steam turbine.
- In 1801, the French inventor Joseph-Marie Jacquard created his punched-card loom, which became a precursor to programmable machines.



Second period (from the 19th century (1801 – 1900) to the 20th century (1901 – 1930))

- It is characterized by the theory of looping and by the applications of Boolean algebra. The first works on looping are due to the Scottish physicist Maxwell (in 1868), the English mathematician Routh (in 1872) and the German mathematician Hurwitz (in 1890), who both gave their name to an algebraic criterion of stability. The analytical study of the stability of the Watt regulator was initiated by Maxwell in 1868 and completed in 1876 by Wichnegradsky.

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Third period, from the 1950s onwards

The emergence of computers and digital calculators revolutionized the world of automation.

- **Today**, automation makes it possible to replace humans in both operational and informational tasks, because automated systems improve:
- **Safety**: automated systems perform tasks that are too complex or too dangerous to be entrusted to humans (for example: control of nuclear power plants).
- **Comfort**: they replace humans in carrying out repetitive or laborious operations, whether at work or in daily life (household appliances, automatic gearboxes, etc.).
- **Quality**: they enhance precision and reduce errors (electronic management of combustion engines, ABS, military applications, etc.).
- **Productivity**: they increase production rates (assembly lines, automated workshops, etc.).

Humans remain essential for supervising and controlling system operations: they handle informational tasks, even though they are relieved from operational tasks.

- **2 – The Profession of an Automation Engineer**

The automation engineer designs, develops, and implements automated control systems in industrial processes. They work on installations where PLC programming, process control, and flow optimization are essential for equipment performance.

- **3 – Main Responsibilities of an Automation Engineer**

- Develop control and regulation diagrams.
- Program industrial PLCs (such as Siemens, Schneider, Allen-Bradley, etc.).
- Design human–machine interfaces (HMI) and supervise SCADA systems.
- Take part in the installation, commissioning, and monitoring of automated systems.
- Diagnose and correct malfunctions.
- Ensure the safety, performance, and energy efficiency of installations.

- **Career Opportunities**

Automation engineers are in demand across many sectors:

- Manufacturing industry (automotive, food processing, pharmaceuticals, etc.).
- Energy production.
- Smart buildings and home automation.
- Automated transportation systems.
- Robotics and Industry 4.0 technologies.

- **Required Qualities of an Automation Engineer**

- Strong skills in electrical engineering, industrial computing, and automation.
- Proficiency in PLC programming languages (ladder, Grafset, ST, etc.).
- Logical, methodical, and rigorous mindset.
- Analytical and problem-solving abilities.
- Teamwork and technical communication skills.
- Responsiveness when facing breakdowns and unexpected issues.

- **Salary of an Automation Engineer**

The salary depends on the sector, experience, and location. At the beginning of a career, an automation engineer earns on average between €2,800 and €3,200 gross per month. With experience, the salary can exceed €4,500 gross per month, particularly in advanced industrial sectors.

- **What Training Is Required to Become an Automation Engineer?**

To become an automation engineer, it is recommended to pursue training in:

- An engineering school specializing in automation, electrical engineering, or industrial computing.
- A Master's degree in automation and robotics, embedded systems, or mechatronics.
- Apprenticeship or work-study programs with internships in industrial environments for better professional integration.

CHAPITRE IV

PROCESS ENGINEERING



• Introduction to Process Engineering

- Since the mid-19th century, applied chemistry—later referred to as “industrial chemistry”—has been considered an integral part of the broader body of knowledge that constitutes chemistry as a science.
- It encompasses not only technical data but also economic, energy-related, and environmental aspects concerning the manufacturing processes of a wide range of industrial products. These include purely synthetic chemical compounds (such as styrene, PET, active pharmaceutical ingredients, atmospheric gases, sulfur, etc.) as well as products derived from processes closely related to the chemical industry (such as plaster, starch, nuclear fuels, electronic components, formulated paints, and adhesives).
- Process engineering is a comparatively younger discipline. Originating in the United States in the early 20th century, it was first known as “chemical engineering.” Essentially, chemical engineering is applied whenever process industries involve the transformation of matter, whether within or beyond the strict domain of the chemical industry.

- **Process engineering** encompasses the set of concepts and methods used to design, size, optimize, and even operate all processes involving the transformation of matter. These processes may involve the production of plastics, pharmaceuticals, drinking water, specialty steels, energy, or the treatment of effluents.
- **Chemical engineering** thus enables the transition from a laboratory-scale synthesis to an industrial process, ensuring its operation while meeting economic, technical, environmental, and safety requirements



- **Role of the Process Engineering Specialist**

- The process or chemical engineering specialist is involved in the design, implementation, and validation of industrial facilities. Their responsibilities include taking into account aspects such as system reliability, safety, and ergonomics.

- Process and chemical engineers are found across all fields of chemistry, including the broader para-chemistry industries (cosmetics, paints, adhesives, materials, agrochemicals, glass, plastics, elastomers, etc.), as well as in diverse sectors such as (pharmaceuticals, energy, automotive, aerospace, nuclear, petroleum, plastics, rubber, materials, and environmental industries...)

Process engineering is a branch of industrial engineering concerned with the design, optimization and control of processes for transforming matter and energy.

It is based on principles of thermodynamics, fluid mechanics, heat transfer and chemical reaction. It is applicable in the following industries:

1. Chemical Industry

In this sector, the engineer designs and improves the manufacturing processes of chemical products such as solvents, plastics, fertilizers, paints, and more. They must ensure the safety, profitability, and quality of the products.

Definition

The chemical industry is the industrial sector that encompasses all activities related to the production and transformation of chemical substances from natural raw materials (oil, gas, minerals, biomass, etc.) in order to manufacture intermediate or finished products, which are used in nearly every area of the economy.

- **Main Characteristics**

- **Transformation of matter:** chemical reactions, physical and biological processes.
- **Intermediate products:** acids, solvents, polymers, fertilizers, dyes, etc.
- **Finished products:** plastics, paints, detergents, cosmetics, pharmaceuticals.
- **Innovation:** development of new materials (nanomaterials, composites, sustainable products).
- **Regulation:** compliance with safety standards and environmental protection.

- **Fields of Application**

- Agri-food (additives, packaging).
- Health (pharmaceuticals, biotechnologies).
- Energy (fuels, batteries, hydrogen).
- Construction (cement, plastics, insulation materials).
- Textile and cosmetics.

-  **In summary:**

The chemical industry is a fundamental sector, as it provides raw materials and essential products for nearly all other industrial fields.

- **2. Pharmaceutical Industry**

- In this sector, the process engineer is involved in the production of medicines. They optimize synthesis, purification, dosing, and packaging processes while ensuring strict compliance with health and safety standards.

- **Definition**

The pharmaceutical industry is the industrial sector that encompasses all activities related to the research, production, quality control, and marketing of medicines designed to prevent, diagnose, treat, or relieve diseases in humans and animals.

- **Main Characteristics**

- **Research & Development (R&D):** discovery of new molecules, clinical trials.
- **Production:** manufacturing of medicines (solid, liquid, injectable forms, vaccines, biotechnological products).
- **Quality control:** ensuring compliance with safety, efficacy, and harmlessness standards.
- **Regulation:** governed by health authorities (WHO, FDA, EMA, etc.).
- **Distribution:** marketing through pharmacies, hospitals, and specialized networks.

- **Role in Society**

- Improvement of public health.
- Increased life expectancy.
- Development of vaccines and treatments for serious diseases (cancer, infectious diseases, chronic illnesses).

-  **In summary:**

The pharmaceutical industry is a cornerstone of public health, as it transforms scientific research into medicines accessible to patients.

3. Petrochemical Industry

In this sector, the engineer designs processes for transforming crude oil into fuels, lubricants, industrial gases, and plastics. This field requires extensive expertise in processes operating under high temperature and pressure conditions.

Definition

The petrochemical industry is a branch of the chemical industry that uses hydrocarbons derived from petroleum and natural gas as raw materials to produce basic chemicals, intermediates, and processed materials.

Main Characteristics

Raw materials: crude oil, natural gas, naphtha, ethane, propane, butane.

Basic products: ethylene, propylene, benzene, toluene, xylenes (known as “building blocks”).

Derived products: plastics (PE, PP, PVC), synthetic fibers, rubber, solvents, detergents, fertilizers, additives.

Processes: cracking, reforming, polymerization, distillation.

Fields of Application

Plastics industry: packaging, pipes, composite materials.

Textile: synthetic fibers (nylon, polyester).

Automotive and aerospace: fuels, lubricants, lightweight materials.

Agrochemicals: fertilizers, pesticides.

Pharmaceuticals and cosmetics: solvents, excipients, chemical ingredients.

In summary:

The petrochemical industry transforms petroleum and natural gas into basic chemicals that serve as the foundation for producing a wide range of consumer goods and industrial materials essential to the modern economy.

- **4 Textile Industry**

- In this sector, process engineering is applied to dyeing, finishing, weaving, and optimizing textile production. Its objectives are to improve quality, reduce energy consumption, and ensure environmental compliance.

- **Definition**

The textile industry is the industrial sector that encompasses all activities related to the production, processing, and commercialization of fibers, yarns, fabrics, and textile products intended for clothing, home furnishings, industrial applications, and technical uses.

- **Main Characteristics**

- **Raw materials:**

- *Natural:* cotton, wool, silk, flax.
- *Synthetic:* polyester, nylon, acrylic.
- *Artificial:* viscose, modal.

- **Production stages:**

- Spinning (conversion of fibers into yarns).
- Weaving or knitting (fabric production).
- Finishing (dyeing, printing, finishing treatments).
- Garment making (manufacture of clothing and textile goods).

- **Innovation:** technical textiles (flame-retardant, waterproof, smart fabrics).

- **Fields of Application**

- Fashion and clothing: garments, accessories.
- Home and furnishings: sheets, curtains, carpets.
- Industry and transport: technical textiles for automotive and aerospace.
- Health: medical textiles (gowns, implants, dressings).
- Sports and safety: sportswear, protective equipment.
-  **In summary:**
The textile industry is a strategic and long-standing sector that combines tradition, innovation, and modernity, providing essential products for daily life as well as for numerous industrial fields.

- **5 Industrial Biotechnology**

- This field involves exploiting microorganisms or living cells to produce substances such as enzymes, biofuels, and vaccines. Process engineering ensures the stability, efficiency, and sterility of these processes.

- **Definition**

Industrial biotechnology (also known as white biotechnology) is a branch of biotechnology that uses microorganisms (bacteria, yeasts, fungi) or enzymes to convert raw materials (often renewable) into products useful for industry, such as biofuels, chemicals, materials, and certain pharmaceuticals.

- **Main Characteristics**

- **Raw materials:** biomass (starch, sugars, vegetable oils, agricultural waste).

- **Processes used:** fermentation, enzymology, genetic engineering, bioreactors.

- **Products obtained:**

- Biofuels (bioethanol, biodiesel, biogas).
- Bioplastics and biodegradable polymers.
- Industrial enzymes (for detergents, textiles, food industry).
- Organic acids and bio-based solvents.

- **Fields of Application**

- **Energy:** production of biofuels to reduce dependence on fossil fuels.
- **Agri-food:** improved preservation, flavors, natural additives.
- **Environment:** waste treatment, pollution control, biological recycling.
- **Materials:** bioplastics, innovative textiles.
- **Pharmaceuticals:** production of therapeutic molecules through biological processes.
-  **In summary:**
Industrial biotechnology aims to replace or complement traditional chemical processes with more sustainable, less polluting, and often more cost-effective biological processes, thereby contributing to the development of the bioeconomy and the green industry.

- **6. Food Industry**

In this sector, the engineer designs food processing methods (pasteurization, sterilization, fermentation, freezing, etc.) while ensuring nutritional quality, food safety, and product preservation.

- **Definition**

The food industry is the industrial sector that encompasses all activities related to the processing, preservation, packaging, and distribution of agricultural and food products intended for human or animal consumption.

- **Main Characteristics**

- **Raw materials:** agricultural products (cereals, fruits, vegetables, milk, meat, fish, oils).

- **Production stages:**

- Collection and supply of raw materials.
- Processing (milling, dairy production, canning, slaughtering, fermentation, etc.).
- Packaging and conditioning (cans, bottles, frozen goods, ready meals).
- Distribution (supermarkets, food service, export).

- **Strict standards:** hygiene, food safety, traceability, sustainability.

- **Fields of Application**
- **Basic products:** flour, oil, sugar, milk.
- **Processed products:** yogurt, biscuits, canned goods, beverages, prepared meals.
- **Specialized nutrition:** baby food, dietary supplements.
- **Animal feed:** forage, compound feeds.
- **Importance**
- A strategic sector for food security.
- Generates significant employment and trade.
- A hub of innovation: functional foods, organic products, plant-based alternatives.
-  **In summary:**
The food industry transforms raw agricultural products into safe, storable foodstuffs tailored to consumer needs, combining tradition with innovation.

Missions of the Process Engineer

- Design and size production units.
- Model and simulate industrial processes.
- Oversee the implementation of installations.
- Optimize costs, efficiency, and environmental impact.
- Ensure process safety and regulatory compliance.
- Contribute to innovation and the development of new products or processes.

Application Domains of Process Engineering

- **Energy:** refining, hydrogen production, biomass.
- **Environment:** water treatment, waste management, CO₂ capture.
- **Pharmaceuticals, cosmetics, and green chemistry.**
- **Advanced materials and nanotechnologies.**
- **Agro-industry, food, and nutrition.**

CHAPITRE V

SUSTAINABLE DEVELOPMENT



Sustainable development is a concept that emerged to address global environmental, social, and economic challenges. It advocates for a development model that meets current needs without compromising the ability of future generations to meet their own. It calls for a balance between economic growth, social well-being, and environmental preservation.



• 2 The Foundations of Sustainable Development

- Sustainable development is based on three fundamental pillars:
- **Economic sustainability:** promoting long-term economic growth without generating harmful imbalances;
- **Social equity:** ensuring fair access to resources and improving quality of life for all;
- **Environmental protection:** preserving ecosystems and biodiversity, and reducing pollution and the use of non-renewable resources.

This tripartite approach is often represented as the "three pillars of sustainability."

- **3 Core Principles of Sustainable Development**

- **Intergenerational responsibility:** safeguarding resources and living conditions for future generations.
- **Precautionary principle:** taking preventive action in the face of uncertainty to avoid irreversible environmental damage.
- **Polluter pays principle:** holding those who cause environmental harm accountable for its remediation.
- **Public participation:** involving citizens and stakeholders in decision-making processes.
- **Integration:** considering social, environmental, and economic dimensions simultaneously in public policy and project design.

• **4Why Is Sustainable Development Essential Today?**

The urgency of sustainable development stems from several global challenges:

- **Climate change:** rising temperatures, sea levels, and extreme weather events,
- **Resource depletion:** overexploitation of fossil fuels, deforestation, and loss of biodiversity,
- **Environmental pollution:** air, water, and soil pollution with consequences for health and ecosystems,
- **Social inequality:** disparities in access to education, healthcare, and employment,
- **Urbanization and consumption:** unsustainable models of production and consumer behavior.

Sustainable development proposes an alternative path that reconciles human progress with respect for planetary boundaries.

• 5 The Stakeholders in Sustainable Development

Many actors are involved in implementing sustainable development policies:

- **Governments:** through legislation, public policy, and international cooperation;
- **Companies:** by adopting corporate social responsibility (CSR) and sustainable production practices;
- **Civil society:** NGOs, citizens, and advocacy groups;
- **International organizations:** such as the UN, UNESCO, and the World Bank;
- **Researchers and universities:** through scientific knowledge and innovation;
- **The media:** for education and public awareness.

• **6 Ecology**

Ecology is the scientific study of interactions between living organisms and their environment. As a cornerstone of environmental science, ecology provides the foundations for understanding and protecting biodiversity, ecosystems, and natural resources.

In the context of sustainable development, ecological principles guide:

- Environmental impact assessments,
- Management of natural areas,
- Conservation strategies,
- Climate adaptation policies.

CHAPITRE VI

SUSTAINABLE DEVELOPMENT ENGINEERING PROFESSION



• 6.1 Introduction

The sustainable development engineer plays a vital role in ecological transition. This professional designs, evaluates, and implements technical, economic, and social solutions that reduce the environmental impact of human activities, while ensuring balanced and sustainable development. Their role is increasingly critical in the context of climate change, resource depletion, and tightening environmental regulations.

• **6.2 Job Description of a Sustainable Development Engineer**

Sustainable development engineers work across various sectors (industry, construction, transportation, agriculture, energy, public services) to integrate environmental sustainability into technical and strategic projects. Their responsibilities may include:

- Designing eco-friendly products,
- Improving the energy efficiency of buildings or industrial processes,
- Managing waste,
- Conducting life cycle assessments (LCA),
- Implementing corporate social responsibility (CSR) policies,
- Ensuring environmental compliance.

• **3 Main Duties of a Sustainable Development Engineer**

Depending on the sector and organization, typical duties may include:

- Conducting environmental or energy audits;
- Designing solutions to reduce ecological impact;
- Drafting environmental specifications;
- Leading continuous improvement projects;
- Advising technical teams on sustainable practices;
- Monitoring and ensuring compliance with environmental regulations;
- Engaging with stakeholders (authorities, clients, NGOs, etc.).

• **6.4 List of Jobs Related to Environment and Sustainable Development**

Here is a non-exhaustive list of careers in this field:

- Environmental Engineer
- Health, Safety, and Environment (HSE) Engineer
- Sustainable Development Officer
- CSR Manager
- Ecodesigner
- Energy Efficiency Specialist
- Sustainable Urban Planner
- Climate Strategy Consultant
- Carbon Footprint Analyst
- Eco-neighborhood Project Manager
- Circular Economy Project Manager
- Renewable Energy Specialist
- Water Treatment Technician
- Biodiversity Engineer

- **6.5 Becoming an Environmental Engineer**

An environmental engineer assesses the environmental impact of projects or activities and proposes solutions to mitigate or compensate for those impacts. They may also design water treatment systems, waste management solutions, or air quality improvement measures. They can work in both public and private sectors, including consulting firms, local governments, industries, or NGOs.

6.6 Training and Education

To become a sustainable development or environmental engineer, several educational pathways are available:

- Engineering degree with a specialization in environment, sustainability, ecological engineering, or HSE;
- Master's degree in environmental science, eco-engineering, or sustainable engineering;
- Specialized schools focusing on ecology, water management, or renewable energy;
- Additional certifications (e.g., university diplomas, ISO 14001, LCA, environmental law, etc.).
- Internships, capstone projects, and field experience are highly valued in this profession.

• **6.7 Main Employers**

Sustainable development engineers may work for a wide range of employers:

- **Industrial companies** (automotive, chemical, food, energy, etc.);
- **Environmental consulting firms** and engineering offices;
- **Local authorities** (municipalities, metropolitan areas, regions);
- **Non-governmental organizations** (NGOs) and environmental associations;
- **Public institutions** (ADEME, Water Agencies, Ministry of Ecological Transition);
- **Green startups** and circular economy enterprises.