



# SCIENCE AND TECHNOLOGY CAREER PATHWAYS II

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SEMESTER II

**University May 8, 1945 Guelma**

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# Chapter 4

## Aeronautics, Mechanical Engineering, Maritime Engineering, and Metallurgy

### Course Outline

**Aeronautics**

**Mechanical Engineering**

**Metallurgy**

**Maritime Engineering**



# Aeronautics

- Aeronautics is the study of the science of flight. In other words, it is the study and practice of designing, building, and operating aircraft. encompassing disciplines such as aerodynamics, propulsion, avionics, materials and structures, and stability and control



# Design Process

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- **Aerodynamics**. is the study of how air flows around the airplane. By studying the way air flows around the plane the engineers can define the shape of the plane. The wings, the tail, and the main body or fuselage of the plane all affect the way the air will move around the plane.
- **Propulsion**. is the study of how to design an engine that will provide the thrust that is needed for a plane to take off and fly through the air. The engine provides the power for the airplane. The study of propulsion is what leads the engineers determine the right kind of engine and the right amount of power that a plane will need
- **Avionics**. Avionics refers to the electronic systems used in aircraft for navigation, communication, monitoring, and control. This includes systems such as autopilots, radar, GPS, communication radios, and flight management systems.

# Design Process

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- Materials and Structures. is the study of what materials are to be used on the plane and in the engine and how those materials make the plane strong enough to fly effectively. The choice of materials that are used to make the fuselage wings, tail and engine will affect the strength and stability of the plane. Many airplane materials are now made out of composites, materials that are stronger than most metals and are lightweight.
- Stability and Control. is the study of how to control the speed, direction, altitude and other conditions that affect how a plane flies. The engineers design the controls that are needed in order to fly and instruments are provided for the pilot in the cockpit of the plane. The pilot uses these instruments to control the stability of the plane during flight.

# The profession of an aeronautics engineer

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- The profession of an aeronautics engineer involves the application of engineering principles to the design, development, testing, and maintenance of aircraft, and related systems.
- Their responsibilities may include:
  - **Design**: Aeronautics engineers design aircraft components, such as wings, fuselages, propulsion systems, and avionics. They use computer-aided design (CAD) software and mathematical models to create and analyze designs.



# The profession of an aeronautics engineer

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- **Development:** Aeronautics engineers are involved in the development of new aircraft technologies.
- **Testing:** Aeronautics engineers oversee testing procedures to ensure the safety, performance, and reliability of aircraft.
- **Manufacturing:** Aeronautics engineers work closely with manufacturing teams to oversee the production of aircraft components.
- **Maintenance and Repair:** Aeronautics engineers are involved in the maintenance, inspection, and repair of aircraft throughout their operational lifespan. They troubleshoot technical issues and implement corrective actions to ensure safety and reliability.

# How to become an aeronautics engineer?

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- Specialized engineering schools in aeronautics engineering
- It is also possible to choose the university path and pursue a Master's degree in aeronautics, energy, or fluid mechanics.
- A Bac +5 (equivalent to a Bachelor's degree plus two additional years of study) is required to become an aeronautics engineer.
- In Algeria, the Saâd Dahleb University of Blida hosts a Department of aeronautics Construction.



# Qualities and skills required for aeronautics engineers?

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- Proficiency in Mathematics, physics, and engineering principles
- It is important to speak several languages, especially English, as the recruiting companies are often international.
- Adherence to strict safety standards and regulations
- Strong communication skills enable effective collaboration and the clear conveyance of technical information within multidisciplinary teams.
- Leadership qualities to lead teams, manage projects, and make critical decisions.
- Continuous learning and professional development: to stay updated with advancements in aeronautics technology and industry practices

# The missions of an engineer in aeronautics

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- The roles of an aerospace engineer encompass various profiles and professions:
  - Within the aeronautics engineering domain, there are numerous roles and professions such as design and conception engineers, calculation engineers, production engineers, and flight test engineers.
  - Each of these roles encompasses a wide range of fields of expertise including electronics, mechanics, aerodynamics, optics, and embedded systems.
  - Additionally, aspects of marketing are also involved as it is crucial to effectively market the parts and aircraft once they are manufactured.

# Main professions in the aeronautics industry

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- Main professions in the aeronautics industry:

- Design drafter
- Aeronautics electronics technician
- Design office engineer
- Aeronautics industry calculation engineer
- Aeronautics structure engineer
- Aeronautics mechanic
- Aeronautics testing manager
- Aeronautics testing technician
- Aeronautics maintenance technician

# Career paths

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- Aeronautics engineers can work:
  - in the commercial aviation industry,
  - for the government and national defense.
  - They can also be hired by aircraft manufacturers such as EADS, Dassault Aviation, or Eurocopter,
  - With engine manufacturers and equipment suppliers such as Snecma, Thales, or Sagem.
  - etc.



# Mechanical engineering

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- Mechanical engineering is a broad and flexible discipline that involves the study of moving objects and systems. It impacts nearly every aspect of contemporary society, from intricate machinery to the human body, which can be viewed as a complex machine.



# The Common misconception

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- The most persistent myth surrounding mechanical engineering is the direct association with automotive mechanics.
- The term "mechanical" in "mechanical engineering" is not linked to the work of automotive mechanics but rather to mechanical physics.



# Brief Chronological Overview of Mechanical Engineering

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- During the Industrial Revolution in the 18th and 19th centuries, mechanical engineering experienced significant advancements, driven by innovations in steam engines, manufacturing processes, and machinery design.
- The 20th century saw rapid growth in mechanical engineering, with the emergence of new technologies such as automobiles, aircraft, and power generation systems.
- In the modern era, mechanical engineering continues to evolve rapidly, with developments in robotics, renewable energy, nanotechnology, and additive manufacturing shaping its future trajectory.

# The Fundamental Law of Dynamics

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- The Fundamental Law of Dynamics, also known as the *2<sup>nd</sup> law of Newton*, is a cornerstone principle in mechanics. It states that the acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.
- Mathematically, this law is expressed as  $\sum \vec{F}_i = m \cdot \vec{a}$  where
  - $\vec{F}$  represents the force applied to the object (measured in Newtons **N**),
  - $m$  is its mass (measured in kilograms **kg**),
  - $\vec{a}$  is its acceleration (measured in meters per second squared **m/s<sup>2</sup>**).
- This law provides a fundamental understanding of how objects move and interact under the influence of forces.



# The Fundamental Law of Dynamics

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- The Universal Law of Gravitation, formulated by Sir Isaac Newton, is a fundamental principle in physics and mechanics. It defines how every object in the universe exerts an attractive force on every other object, proportional to the product of their masses and inversely proportional to the square of the distance between them.
- Mathematically, this law is expressed as  $F = G \frac{m_1 m_2}{r^2}$  where
  - $F$  represents the gravitational force (measured in Newtons, **N**),
  - $G$  is the gravitational constant, ( $6.67430 \times 10^{-11}$  **N.m<sup>2</sup>/kg<sup>2</sup>**)
  - $m_1$  and  $m_2$  are the masses of the two objects (measured in kilograms, **kg**),
  - $r$  is the distance between their centers (measured in meters, **m**).

# Fields of Mechanical Engineering

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- Mechanical engineering plays a vital role in various high-tech product manufacturing and design processes across multiple industries:
  - Production and maintenance of industrial equipment
  - Production, transportation, and energy transformation
  - Aerospace and aeronautics
  - Naval industry
  - Military industry
  - Automotive industry
  - Construction machinery
  - And more

# Specializations in Mechanical Engineering

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- The three main specializations available to mechanical engineers can be summarized as follows:
  - Mechanical construction (design - engineering office)
  - Mechanical manufacturing
  - Thermal or energy engineering

# Responsibilities of a Mechanical Engineering Engineer

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- Mechanical engineers are involved in the design of products, systems, and machinery that involve motion, such as airplanes, ships, weapons, satellites, robots, turbines, pumps, engines, heating systems, refrigeration and air conditioning systems (mass and heat transfer), etc.
- They are responsible for creating prototypes and developing new products for the company, often working within an engineering office. They also oversee the production of these products from start to finish.
- Mechanical engineers oversee the manufacturing process.
- They provide advice to the company and clients, assessing risks and techniques used in product development.
- Lastly, they supervise the installation and introduction of the product to the market, as well as its maintenance.



# Disciplines of Mechanical Engineering

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- Presented in the order of a mechanical product's lifecycle.
- Product Design: Functional analysis, Computer-Aided Design (CAD).
- Mechanics: Study of motion and forces: Dynamics, Statics, Strength of Materials.
- Mechanical Construction: Dimensioning and calculations of standard elements (cylinders, gears, belts, etc.), industrial drawing.
- Industrialization Service: Manufacturing processes, Computer-Aided Manufacturing (CAM).
- Production Management: Manufacturing Resource Planning.
- Production: Production processes.
- Automation.
- Metrology.
- Quality Assurance.
- Maintenance: Computerized Maintenance Management System (CMMS).
- Recycling

# Career Opportunities

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- Mechanical engineers have diverse career opportunities in various fields of activity, both in small and medium-sized enterprises and large corporations:
  - Industry
  - Transportation
  - Aerospace and aviation
  - Defense
  - Medical and biomechanics
  - Sports and leisure equipment
  - Machine tools
  - Consumer goods
  - Food industry (agri-food industry)
  - Metallurgy
  - Electronics
  - Information technology
  - Energy production
  - Telecommunications
  - Research and development
  - And more..

# Required Qualities of a Mechanical Engineering Engineer

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- A mechanical engineering engineer must:
  - Possess strong scientific, technical, and methodological skills.
  - Be capable of understanding industrial activity in its entirety (technical, economic, social, and environmental aspects).
  - Have a high level of general culture and a broad openness to the industrial world.
  - Master at least one foreign language (English nowadays).
  - Be capable of coordinating and managing teams.
  - Demonstrate curiosity, responsiveness, and flexibility to stay at the forefront of innovative techniques.

# Metallurgy

- Metallurgy is a branch of materials science and engineering that explores the properties, processing, and applications of metallic elements, as well as their combinations in the form of alloys.
- This field delves into understanding the structural, physical, and chemical characteristics of metals, intermetallic compounds, and alloys, aiming to manipulate their properties for various industrial purposes.
- Metallurgy is an ancient science that dates back many years.





# The three main specialties of the metallurgy industry

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- *Production of iron, steel, and ferrous alloys (known as metallurgy):* This includes the manufacturing processes related to iron, steel, and their alloys.
- *Production of non-ferrous and non-precious metals:* Encompasses the processes involved in producing metals other than iron and precious metals.
- *Production of precious metals (such as gold, silver, etc.):* Concentrates on the extraction and processing of valuable metals like gold, silver, platinum, and others.

# Industrial activities of metallurgy

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- Metallurgy encompasses a wide array of industrial activities, including:
  - **Ore Extraction and Initial Processing :** Involves extracting ore from the earth and initial processing to prepare it for further refinement.
  - **Metal Recycling:** Utilizing scrap metal and waste materials to recycle and reuse metals, contributing to sustainability efforts.
  - **Foundry Operations (Blast furnaces and refining):** Foundries play a crucial role in melting metals and refining them to produce castings of desired shapes and properties.
  - **Production of Raw Products via Rolling Mills:** Raw materials are processed through rolling mills to produce various shapes and forms, such bars, and rods.
  - **Transformation of Raw Products into Semi-Finished Goods:** Further processing of raw products to create semi-finished goods with specific characteristics.
  - **Manufacture of Equipment and Finished Products:** Utilizing metallurgical materials to manufacture machinery, equipment, and finished products for industrial, construction, and transportation purposes.

# Role of the Metallurgical Engineer

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- The metallurgical engineer conducts studies on the properties and characteristics of materials and ores and plans, conceptualizes, and tests machinery and processes for the treatment of metals, alloys, and other materials.
- Above all, the metallurgical engineer must master the physical, chemical, and mechanical properties of metals, as well as the characteristics of manufactured products and the techniques used in the company.

# Career Opportunities in Metallurgy

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- Metal forming techniques determine the major sectors of employment in metallurgy:
  - Foundry (Casting techniques)
  - Forge (Working with metals at high temperatures)
  - Boiler-making (working with cold metals)

# Missions of the Metallurgical Engineer

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- The metallurgical engineer's mission is to select or develop high-performance materials adapted to each production or technical problem. Therefore, their work is heavily focused on research, where they define the content and cost.
- In collaboration with project managers, the metallurgical engineer conducts technical and economic audits to optimize manufacturing processes, solve production problems, or enhance alloy performance to make them more resistant to corrosion



# Plastics engineering

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- Plastics engineering refers to the field dedicated to working with plastic materials. This field encompasses a wide range of techniques and processes involved in transforming raw plastic materials, known as polymers, into various products and components
- Types of Plastic Materials:
  - **Thermoplastics:** These plastics can be melted and reformed multiple times without undergoing significant chemical changes.
  - **Thermosetting Plastics:** Unlike thermoplastics, thermosetting plastics undergo irreversible chemical reactions during processing, resulting in a permanent change in their structure. They cannot be melted and reformed after they have been cured.

# Career Opportunities in Plastics Engineering

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- Jobs in plastics engineering involve design, production, maintenance, and various cross-functional roles such as quality assurance, research and development, sales, and marketing.
- With only 50 years of existence, it is a young, innovative industry that creates jobs. Present in all areas of our daily lives, plastic is the material of the 3rd millennium. As plastic is omnipresent, job opportunities are very diverse: packaging, automotive, construction, aerospace, medical, etc.
- To compete internationally and reduce dependence on oil prices, industry professionals are focusing on research and development of alternative products: smart plastics, biomaterials, composite materials, etc.

# Maritime Engineering

- Maritime Engineering involves the design, construction, and maintenance of structures like ships, offshore platforms, ports, and coastal infrastructure. It encompasses a wide range of disciplines, including naval architecture, marine engineering, oceanography, and coastal engineering. The goal of maritime engineering is to develop safe, efficient, and sustainable solutions for marine transportation, offshore energy production, and coastal development.



# Role of Maritime Engineering

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- Maritime Engineering involves training engineers with skills enabling them to participate in the design, development, and operation of complex systems in marine, underwater, and coastal environments:
  - Mastery of scientific and technical knowledge in maritime engineering,
  - Proficiency in modeling, simulation, measurement, and testing tools for fluids and structures,
  - Fundamental knowledge in mechanics, energetics, materials, and automation
- Maritime engineering can be divided into military maritime engineering and civil maritime engineering

# Maritime Engineering Field in Algeria

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- In Algeria, the Maritime Engineering field is divided into two specialties:
  - Naval Architecture and Navigation
  - Naval Equipment Engineering
- Currently, the USTO-MB (Université des Sciences et de la Technologie d'Oran - Mohamed Boudiaf) is the only Algerian university offering academic training programs in this field.



# Profession of the Naval Architect

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- The job of a naval architect is practiced within the framework of both leisure navigation and service navigation.
- A naval architect is responsible for designing various types of marine vessels, including ships, boats, and offshore structures.
- The naval architect divides their time between their design office, the workshop where the vessel is designed, and their clients.

# The Naval Architect

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- A naval architect is responsible for the design and construction of boats and other marine structures. Their role includes:
  - Establishing the technical and regulatory plans of the boat.
  - Determining the equipment and materials necessary for the construction of the boat.
  - Performing calculations of resistance, consumption, weight, etc.
  - Overseeing the design of the boat until its launch.

# The Naval Equipment Engineer

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- The naval equipment engineer is responsible for designing, developing, producing, and testing maritime systems, including:
  - Hull systems,
  - Propulsion systems (diesel engines, gas turbines),
  - Fire suppression systems,
  - Ship machinery,
  - Electrical systems, air distribution systems, electromechanical systems, and other related ship equipment.

# Potential Employers

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- At the national or international level, potential employers mainly include:
  - Shipyards
  - Maritime companies
  - Companies specializing in underwater work
  - Engineering firms
  - Maritime consulting firms
  - Armed forces (civil or military positions)
  - Government agencies
  - Manufacturers of watercraft

# Courses in Maritime Engineering

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- Viscous fluid mechanics
- Hydrodynamics (waves, potential flows)
- Heat and mass transfer, contaminant dispersion
- Wave-structure interaction, currents, bathymetry
- Ocean currents
- Solid mechanics
- Applied numerical modeling to free surface flows
- Instrumentation techniques (measurement, sensors, metrology, practical work at sea)
- Materials, physicochemical properties, corrosion



# Courses in Maritime Engineering

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- Complex and porous media: mechanics and dynamics
- Applied hydrodynamics, Fluid/offshore structure
- Marine renewable energies
- Environmental risks
- Submarine systems and installations

# Career Opportunities

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- This unique training program offers numerous career opportunities at both national and international levels in various fields such as:
  - Offshore oil and gas industry,
  - Offshore construction and port engineering,
  - Marine renewable energies,
  - Coastal protection and onshore structures,
  - Underwater robotics and oceanography.