# BACHELOR OF ENGINEERING IN MECHANICAL ENGINEERING

**Main Language of Instruction:**
French ☑ English ○ Arabic ○

**Campus Where the Program Is Offered:** CST

## OBJECTIVES

The Bachelor of Engineering in Mechanical Engineering aims to graduate students able to:

- Advance in their careers in various sectors at local, regional, and international levels while respecting ethical and professional conducts.
- Successfully pursue higher education in world-class universities.
- Become decision-makers, innovators, and leaders in their profession.

## PROGRAM LEARNING OUTCOMES (COMPETENCIES)

- The ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
- The ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
- The ability to communicate effectively with a range of audiences.
- The ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, considering the impact of engineering solutions in global, economic, environmental, and societal contexts.
- The ability to function effectively on a team, where members provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
- The ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
- The ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

## PROGRAM REQUIREMENTS

**180 credits: Required courses (150 credits), Institution's elective courses (26 credits), Open elective courses (4 credits).**
**USJ General Education Program (26 credits - part of the above categories)**

**USJ General Education Program (26 Cr.)**
*10 additional credits are earned at the Department of Preparatory Classes*
**English (4 Cr.)**
English Level A (4 Cr.)
**Arabic (4 Cr.)**
One Arabic Culture and Language course (2 Cr.) to be selected between:
Arabic Language and Media (2 Cr.)
Arabic Language and Arts (2 Cr.)
Arabic Language: Contemporary Novel, Cinema, and Theater (2 Cr.)
Business Law (2 Cr.)
**Humanities (4 Cr.)**
Business Ethics (4 Cr.)
**Social Sciences (6 Cr.)**
Project Management (4 Cr.)
One Institution's elective course (2 Cr.) to be selected between:
Work Ready Now (2 Cr.)
Entrepreneurship (2 Cr.)

**Communication Techniques (8 Cr.)**
Communication Skills (2 Cr.)
Multidisciplinary Project (2 out of the 6 credits of the course)
Final Year Project (4 out of the 16 credits of the course)

**Fundamental Courses**

**Required Courses (150 Cr.)**
Accounting (4 Cr.). Automobile (4 Cr.). Business Ethics (4 Cr.). Business Law (2 Cr.). Communication Skills (2 Cr.). Computer Aided Drawing and Design (CADD) (4 Cr.). C++ Programming (4 Cr.). Electronics (6 Cr.). English Level A (4 Cr.). Finite Elements for Mechanical Applications (4 Cr.). Fluid Mechanics (6 Cr.). Heat Transfer (6 Cr.). HVAC 1 (4 Cr.). Hydraulics (4 Cr.). Innovation and Design Thinking (2 Cr.). Introduction to Electric Machines (4 Cr.). Linear Control (6 Cr.). Machine Design 1 (4 Cr.). Management (4 Cr.). Mechanical Systems (6 Cr.). Mechanical Vibrations (4 Cr.). Numerical Methods (4 Cr.). Plumbing (4 Cr.). Project Management (4 Cr.). Renewable Energy (6 Cr.). Sensors and Instrumentation (4 Cr.). Statistics (4 Cr.). Strength of Materials (6 Cr.). Thermodynamics: Principles and Applications (6 Cr.)

Corporate Internships (2 Cr.) – During their studies, each student can complete two internships:
- A recommended labor internship of at least 4 weeks at the end of the third year of studies.
- A required technical internship of 6 to 10 weeks at the end of the fourth year of studies (2 Cr.).

Multidisciplinary Project (6 Cr.)
This project brings together students from different programs and/or options where each student participates in the execution of a task related to their field. It aims to provide hands-on design experience, strengthen their analysis capacity, and develop their communication skills and teamwork ability. In this project, students must apply the knowledge acquired throughout their academic years of study and provide a final product that went through all stages of design, modeling, analysis, testing and evaluation. A final report and an oral presentation are the main deliverables of the project.

Final Year Project (16 Cr.)
The final year project is carried out by groups of 2 to 4 students, aiming to deliver practical design experience in computer and communications engineering under the supervision and approval of a faculty member. Students must define the project, specify its objectives, perform a state of the art of the studies topic, establish the project specifications and select a design method. In this project, students must apply the knowledge acquired throughout their academic years of study and provide a final product that went through all stages of design, modeling, analysis, testing and evaluation. A final report and two oral presentations are the main deliverables of the project.

**Institution's Elective Courses (26 Cr.)**
Entrepreneurship (2 Cr.). Work Ready Now (2 Cr.)

*Energy Track:*
Aerodynamics (4 Cr.). Automotive Propulsion Systems (4 Cr.). Energy Optimization (4 Cr.). HVAC 2 (4 Cr.). Numerical Fluid Mechanics CFD (4 Cr.). Pollution, Environment and Sustainability (4 Cr.). Power Generation (4 Cr.). Profitability of Energy Projects (4 Cr.). Refrigeration Systems (4 Cr.). Thermal Engines (4 Cr.). Turbomachines (4 Cr.)

*Mechanical Design Track:*
Acoustics and Vibrations (4 Cr.). Advanced Materials Science (4 Cr.). Advanced Strength of Materials (4 Cr.). Biomechanics (4 Cr.). Design of Mechanisms (4 Cr.). Fluid Power Systems (4 Cr.). Machine Design 2 (4 Cr.). Manufacturing Processes 1 (4 Cr.). Manufacturing Processes 2 (4 Cr.). Mechanics of Composite Materials (4 Cr.). Selection and Properties of Materials (4 Cr.)

*Mechatronics Track:*
Artificial Intelligence (4 Cr.). Design of Mechatronic Systems (4 Cr.). Dynamic Systems Modeling (4 Cr.). Home Automation (4 Cr.). Hydraulic Servo Systems (4 Cr.). Machine Learning (4 Cr.). Mechatronics and Intelligent Machines (4 Cr.). Micro-Electro-Mechanical Systems (4 Cr.). Modern Control (4 Cr.). Robotics (4 Cr.). Wheeled Robots (4 Cr.)

**Open Elective Courses (4 Cr.)**
Arabic Culture and Language (2 Cr.). One Open Elective Course (2 Cr.)

## SUGGESTED STUDY PLAN

### Semester 1

| Code | Course Name | Credits |
|---|---|---|
| 020PCPES2 | C++ Programming | 4 |
| 020ELCES1 | Electronics | 6 |
| 020MEFES1 | Fluid Mechanics | 6 |
| 020STAES1 | Statistics | 4 |
| 020RDMES1 | Strength of Materials | 6 |
| 020TPAES1 | Thermodynamics: Laws and Applications | 6 |
| | Institution's Elective course: Work Ready Now or Entrepreneurship | 2 |
| | **Total** | **34** |

### Semester 2

| Code | Course Name | Credits |
|---|---|---|
| 020TCOES4 | Communication Skills | 2 |
| 020TRCES2 | Heat Transfer | 6 |
| 020CL1ES2 | HVAC 1 | 4 |
| 020IMEES1 | Introduction to Electric Machines | 4 |
| 020SMEES1 | Mechanical Systems | 6 |
| 020VMEES2 | Mechanical Vibrations | 4 |
| 020MENES2 | Numerical Methods | 4 |
| | Open Elective: Arabic Language and Culture | 2 |
| | **Total** | **32** |

### Semester 3

| Code | Course Name | Credits |
|---|---|---|
| 020AUTES3 | Automobile | 4 |
| 020CAOES2 | Computer Aided Drawing and Design | 4 |
| 020HYDES3 | Hydraulics | 4 |
| 020AULES2 | Linear Control | 6 |
| 020CM1ES3 | Machine Design 1 | 4 |
| 020GPRES2 | Project Management | 4 |
| 020CEIES3 | Sensors and Instrumentation | 4 |
| | Institution's Elective course | 4 |
| | **Total** | **34** |

### Semester 4

| Code | Course Name | Credits |
|---|---|---|
| 020ETHES3 | Business Ethics | 4 |
| 020DROES5 | Business Law | 2 |
| 020ANGES4 | English | 4 |
| 020INDES2 | Innovation and Design Thinking | 2 |
| 020PRMES4 | Multidisciplinary Project | 6 |
| 020PLBES4 | Plumbing | 4 |
| | Institution's Elective course | 8 |
| | Open Elective | 2 |
| | **Total** | **32** |

### Semester 5

| Code | Course Name | Credits |
|---|---|---|
| 020CMPES5 | Accounting | 4 |
| 020STGES5 | Corporate Internship | 2 |
| 020ELFES4 | Finite Elements for Mechanical Applications | 4 |
| 020MNGES4 | Management | 4 |
| 020ERNES5 | Renewable Energy | 6 |
| | Institution's Elective course | 12 |
| | **Total** | **32** |

### Semester 6

| Code | Course Name | Credits |
|---|---|---|
| 020PFEES6 | Final Year Project | 16 |
| | **Total** | **16** |

## COURSE DESCRIPTION

**020CMPES5 Accounting 4 Cr.**

Topics covered include: Definition of Accounting, Accounting Process, Accounting Concepts, Classification of Accounts, Rules of Double Entry Accounting System, Rules of Journal, Current Assets, and Current Liabilities. Concepts of Cost Accounting, Advantages of Cost Accounting, Classification and Elements of Cost, and Preparation of Cost Sheet.

**020AEVES4 Acoustics and Vibrations 4 Cr.**

This course covers the fundamental concepts in noise and vibrations, the vibrations of bars, beams, and membranes, passive and active damping strategies, damping materials, control methods; and applications. **Prerequisite:** Mechanical Vibrations (020VMEES2) or Vibrations (020VIBES2).

**020SMAES4 Advanced Materials Science 4 Cr.**

This course deals with metals and polymers. The ferrous and non-ferrous alloys section covers the following aspects: mechanical behavior of metals, phase diagrams; fabrication of metals, heat treatment, surface properties of metals; plastic deformation, elements of fracture mechanics; and process-structure-property relationships. The polymers' part covers their properties, polymerization and synthesis, characterization techniques, physical properties of polymers, viscoelasticity, mechanical properties and applications.
**Prerequisite:** Introduction to Materials Science (020ISMNI2 or 020ISMCI2).

**020RMAES4 Advanced Strength of Materials 4 Cr.**

This course focuses on the study of stresses resulting from combined loadings, beam deflection, principal stresses, and absolute maximum shear stress. It also covers experimental methods for determining deformation, column buckling, and static failure theories. Students will explore statically indeterminate problems, which are common in real-world scenarios and cannot be solved using statics alone. The course introduces various solution methods, including integration, superposition, and Clapeyron's theorem, to determine reactions at the supports of statically indeterminate members under tension, torsion, bending, and buckling. Additionally, the course covers the virtual work theorem, energy methods, static failure theories, and the three-dimensional state of stress using Mohr's circle. Topics also include stresses in thin-walled pressure vessels, composite and curved beams, shear centers, and asymmetric bending. The course further addresses the plastic analysis of bars, beams, and shafts with elastic-perfectly plastic material, as well as two-dimensional problems in elasticity.
**Prerequisite:** Strength of Materials (020RDMES1) or Strength of Materials 1 (020RM1ES2).

**020ARDES3 Aerodynamics 4 Cr.**

This course covers theoretical and empirical methods for calculating the loads on airfoils and finite wings by application of classical potential theory, thin airfoil approximations, lifting line and lifting surface theory, and panel methods; wings and airplanes; application of linearized supersonic flow to supersonic airfoils; performance and constraint analysis; longitudinal stability and control.
**Prerequisite:** Fluid Mechanics (020MEFES1) or Fluid Mechanics 1 (020MF1ES1).

**020IA3ES4 Artificial Intelligence 4 Cr.**

This course aims to study artificially intelligent agents. It portrays several methods of implementing these agents: from simple reflex agents to utility-based agents as well as learning agents. It first covers greedy and A* search, the implementation of games through the Minimax and Expectimax algorithms, Markov Decision Processes (MDP) and Reinforcement Learning (RL). It then introduces Machine Learning (ML) algorithms with some applications such as regression and classification. Finally, these algorithms are applied to realistic datasets via Python implementations using libraries such as Scikit-learn, Tensorflow and Keras.

**020AUTES3 Automobile 4 Cr.**

This course introduces students to automotive engineering, it deals with several systems in an automobile such as clutches, manual and automatic gearboxes, torque converter, 4x4 transfer, CV joints, transmission, differential, suspension, wheel geometry, steering box, and braking systems.
**Prerequisite:** Mechanical Systems (020SMEES1).

**020SPAES5 Automotive Propulsion Systems 4 Cr.**

This course covers the basics of transmission systems and ground propulsion, energy consumption and the environmental impact of modern means of transport, configuration of conventional vehicle propulsion systems, principles of operation of conventional propulsion systems, technologies of propulsion systems for battery electric vehicles, technologies of propulsion systems of fuel cell vehicles, hybrid electric powertrain technologies, stop/start of hybrid, parallel hybrid and series/parallel hybrid drive systems.
**Prerequisites:** Automobile (020AUTES3), Thermal Engines (020MOTES4).

**020BIMES3 Biomechanics 4 Cr.**

This course explores the biomechanical principles underlying the kinetics and kinematics of both normal and abnormal human motion, with an emphasis on the interaction between biomechanical and physiological factors (bones, joints, connective tissues, and muscle physiology and structure) in skeletal and motor function. It also covers applications in testing and rehabilitation practice. Additionally, the course introduces constitutive equations, stress-strain relationships for biomaterials, rheological properties of blood, and the biomechanics of blood vessels and the heart.
**Prerequisites:** Introduction to Materials Science (020ISMNI2 or 020ISMCI2), Mechanical Systems (020SMEES1).

**020ETHES3 Business Ethics 4 Cr.**

This course is interactive in nature. It includes readings and analysis of basic texts, moments of reflection and debate, awareness of the state-of-the-art in the region, studies of authentic international organizational documents, role plays and projects for a more pragmatic analysis. It is aimed at students destined to work in public or private companies and in all fields. Its objective is to create awareness for the need of ethics, which is becoming inescapable today, given current trends towards sustainable development, the dissemination of information to stakeholders and transparent competition. It also offers prospective engineers the opportunity to understand business issues from an analytical perspective and to distinguish themselves by their professionalism and informed attitude about ethics. Finally, students will be more alert to the entrepreneurial approaches and the ethical reflection that accompanies it.

**020DROES5 Business Law 2 Cr.**

This course provides an overview of the legal framework governing commercial activities and business entities. It covers fundamental concepts related to commercial transactions, the status of merchants, and the regulations governing business establishments.

**020TCOES2 Communication Skills 2 Cr.**

Communication is of high importance for an engineering student. Indeed, whether in academic or professional activities, transmitting information is a powerful tool for convincing and even influencing others. Communication is unavoidable, but it comes with many errors and risks that should be avoided. Otherwise, the reception of the information may be disturbed and misunderstood. This course offers students the knowledge of essential basic rules of main ways of communication (written, verbal and non-verbal) and makes them aware of the errors to be avoided.

**020CAOES2 Computer Aided Drawing and Design (CADD) 4 Cr.**

This course covers computer aided drawing and design (CADD). Students will employ these powerful tools in the solution of various mechanical engineering problems. CADD includes all the modeling programs and techniques that allow the design of models and products. It also makes it possible to simulate and therefore virtually test products before manufacturing them so that it is then easy to transmit the information to Computer Aided Manufacturing (CAM). The course also enables students to identify several stages: (a) Creation of a model of the object, (b) Analysis, testing and simulations, (c) Construction of virtual prototypes, (d) Management of large assemblies. It utilizes SolidWorks software for drawing, analysis, design, and testing of mechanical systems and applications.

**020STGES5 Corporate Internship 2 Cr.**

The corporate internship is a learning opportunity for students to: apply the knowledge they acquired during earlier coursework in a professional environment - acquire professional skills in addition to the theoretical and practical training – experience situations of human relationships that occur in the different environments where engineers may work - acquire experience and knowledge that facilitate future professional integration.

**020PCPES2 C++ Programming 4 Cr.**

Topics covered include: Structure of a C++ program (declarations, statements, literals, operators), control statements (conditional statements and loops), functions, arrays, structures. Object-oriented programming: Classes and objects, construction, encapsulation, inheritance, virtual functions, abstract classes and polymorphism, operator overloading, exception handling, file handling, generic programming with templates, the Standard Template Library (STL), graphical interfaces with Qt.
**Prerequisite:** Programming 2 (020IF2NI3 or 020IF2CI3).

**020CPMES3 Design of Mechanisms 4 Cr.**

This course focuses on the graphical and analytical synthesis of linkage mechanisms to one or more loops for the generation of movements, trajectories and generation of functions from 2-3-4 and 5 precision positions; optimal synthesis of linkage mechanisms; synthesis of cam-follower mechanisms; synthesis of gear trains.
**Prerequisite:** Mechanical Systems (020SMEES1).

**020CSMES4 Design of Mechatronic Systems 4 Cr.**

This course offers a comprehensive understanding of mechatronics and microcontroller systems, emphasizing the integration of mechanical components, electronics, and data-driven control. Students will explore topics such as numbering systems, microcontroller architecture, assembly language programming, A/D and D/A conversion, parallel I/O, programmable timer operation, and the interfacing of sensors and actuators. Through theoretical knowledge, students will develop the skills required to design and implement mechatronic systems for various applications. Furthermore, they will collaboratively engage in a team project focused on applying these skills to real-world scenarios.
**Prerequisite:** Sensors and Instrumentation (020CEIES3).

**020MSDES1 Dynamic Systems Modeling 4 Cr.**

The aim of this course is to introduce and train students to the crucial importance of modeling and analysis in the industry nowadays that leads to performance improvement, better time management and manufacturing cost reduction of a given product. These goals are taught through examples of electrical, mechanical, thermal, and complex systems. Pre-sizing, modeling, analysis of operation and performance are performed through simulations using the advanced software MATLAB/Simulink. This course initiates engineering design to students through iterative improvements, feasibility study and process optimization before the usual industrial prototyping.
**Prerequisite:** MATLAB (020MATNI4).

**020ELCES1 Electronics 6 Cr.**

This course introduces the basics of electronics and electronic circuits to students in the mechanical engineering program. Its objectives are to provide a concise treatment of the basic concepts of electronic components and to introduce students to basic analog and digital circuits. The course covers the basics of diodes, semiconductors, transistors, operational amplifiers and their applications, digital circuits and systems, and basic instrumentation.
**Prerequisite:** Linear Electrical Systems and Networks (020SRLNI4 or 020SRLCI4).

**020OEPES5 Energy Optimization 4 Cr.**

This course examines the energy audit methods for industrial processes and the systematic mathematical methods of energy efficiency and energy, economic and environmental optimization of these processes by the application of the pinch method. The pinch method is a relatively recent method (it dates back to the 1980s), which makes it possible to determine the most efficient network of heat exchangers and utilities in an energy installation or an industrial process. It is based on thermodynamic principles and on the study of the thermal heat transfer between the streams to be cooled (availability) and heated (needs). It makes it possible to minimize the internal irreversibility of the heat exchanger network, and thus to improve its performance.
**Prerequisite:** Heat Transfer (020TRCES2).

**020ANGES4 English 4 Cr.**

This course is designed to develop critical thinking, reading, oral and writing skills. It focuses on synthesizing sources producing a research paper and defending it in front of an audience. Emphasis is on the analytical reading of different text types required in the courses as well as on synthesis from a variety of sources to produce a written text and present it orally.

**020ENTES1 Entrepreneurship 2 Cr.**

Topics covered include: Design thinking, Problem tree, Business Model Canvas, Presentation – Value Proposition Canvas, Customer segmentation (Product-market fit), Competitive analysis, Go2market strategy, Presentation – Basic budgeting and financial figures, Pitch deck, Presentation.

**020PFEES6 Final Year Project 16 Cr.**

The final year project is a culminating major engineering design experience carried out by groups of 2 to 4 students under the supervision of a faculty member. Students must define the project, specify its objectives, perform a state of the art of the studies topic, establish the project specifications and select a design method. In this project, students must apply the knowledge acquired throughout their academic years of study and provide a final product

that went through all stages of design, modeling, analysis, testing and evaluation. A final report and two oral presentations are the main deliverables of the project.
**Prerequisite:** Validate 150 credits

**020ELFES4 Finite Elements for Mechanical Applications 4 Cr.**

The finite element method is a widely used numerical simulation technique in engineering and research across various technical and scientific fields. The objective of this course is to introduce students to the theoretical foundations and numerical implementation of the finite element method, with a focus on problems in the mechanics of materials and heat transfer. Students will learn to solve second-order differential equations in one and two dimensions with one or two variables. The course covers the stiffness method and/or weak formulations to derive finite element models. Applications include problems involving bars, trusses, beams, heat exchangers, frames, and plane stresses and strains in elasticity. Both symmetric and asymmetric problems are also addressed. Additionally, the course enables students to effectively use finite element software (Abaqus) and interpret and validate results.
**Prerequisites:** Numerical Methods (020MENES1), Strength of Materials (020RDMES1) or Strength of Materials 1 (020RM1ES2).

**020MEFES1 Fluid Mechanics 6 Cr.**

This course provides an in-depth understanding of fluid mechanics principles and their applications in mechanical engineering. Students will explore the fundamental concepts of fluid behavior, fluid statics, fluid dynamics, and the practical aspects of fluid flow in mechanical processes. The course emphasizes the analysis and design of fluid systems, including the fundamental elements for understanding incompressible and compressible fluid flow using mass, momentum, energy conservation principles and resolution of the characteristic fluid flow equations through the application of analytical and analogous methods.
**Prerequisite:** Mechanics 2 (020MC2CI3 or 020MC2NI3).

**020OFPES4 Fluid Power Systems 4 Cr.**

This course provides an overview of the latest technologies and developments in fluid power systems, as well as the diversity of their applications. It aims to make students aware of the potential and specificities of the application of different systems and components in the engineering world, from aviation to industrial machinery. The covered topics are technology, operation, maintenance, troubleshooting, design and analysis of different fluid power systems and their components, such as positive displacement pumps and motors, hydraulic actuators and servomechanisms, different types of valves (pressure and flow regulating valves), selector valves, servo-valves, different filtration and fluid conditioning systems, electric and automatic control components and sensors for different fluid power systems.
**Prerequisites:** Hydraulics (020HYDES3), Computer Assisted Drawing (020DAMNI4 or 020DAMCI4).

**020TRCES2 Heat Transfer 6 Cr.**

The course covers the fundamental concepts and conduction, convection and heat transfer by radiation, as well as their application to the solution of thermal engineering problems. The course also covers stationary thermal conduction and transient regime; flat surfaces; numerical simulations of conduction in one-dimensional and two-dimensional problems; external and internal forced convection applied to laminar and turbulent flows; natural convection; principles of the heat exchanger; and thermal radiation, form factors and radiation exchange between diffuse and gray surfaces.
**Prerequisite:** Introduction to Heat Transfer (020ITCNI3 or 020THENI3) or Thermodynamics 2 (020TH2CI4).

**020DOMES3 Home Automation 4 Cr.**

Topics covered include: Introduction to Home Automation. Communication mode: Dry contact, Serial, Infrared and TCP-IP. Protocol: Wired and Wireless, Dedicated and Universal. Type of control: Lighting, electrical curtains, HVAC and Audio video equipment. Interface with other systems: Building management systems (BMS), Fire Alarm, Intrusion, CCTV and intercom. Internet of things (IOT). User Interface: Binary input, Wired Keypads, Wireless remote control, Touch screen and Mobile / Tablet applications. Concept of electrical installation relative to home automation complete with the relative electrical panel. Load schedule with the number of circuits and type of control. Home Automation devices. KNX Protocol. ETS software. Concept of typical project (requirement and recommendations).

**020CL1ES3 HVAC 1 4 Cr.**

Topics covered include: Thermal Comfort: Thermal and Hydrothermal Exchange - Interior Basic Conditions - Exterior Basic Conditions - Comfort Elements: Activity, Clothes, Hygrometry, Radiation, Temperatures - Psychometric Chart: Calculation and dimensioning of heating, Cooling, Humidifying, Dehumidifying systems for interior ambient - Load Estimation for Heating taking in account the Impacts of Ventilation, Wall insulation, Glazing treatment, Lighting and Equipment heating production, etc. - Central Heating using Hot Water: Presentation, Design and sizing of radiators, Fan-coils, Floor heating, Convectors, Pipes, Pumps, Boilers, Burners, Domestic hot water, Fuel tanks, Chimney, etc. - Heating with Hot Air: Production of hot air, Air handling unit, Fan coil unit - Presentation, Design and sizing using the psychometric chart of heating coils, Humidifiers, Air filters, Fans, Mixing box.
**Prerequisites:** Fluid Mechanics (020MEFES1) or Fluid Mechanics 1 (020MF1ES1), Thermodynamics 2 (020TH2CI4) or Introduction to Heat Transfer (020ITCNI3 or 020THENI3).

**020CL2ES4 HVAC 2 4 Cr.**

Topics covered include: Heat pump – Mollier diagram – Environmental issues related to cooling fluids (Ozone and global warming) and new fluids – Summer thermal balance sheet – Cold battery and air evolution on cold batteries – Direct and indirect expansion air conditioning modes – Low and high-speed duct systems – Single and double flow and variable air flow.
**Prerequisite:** HVAC 1 (020CL1ES3).

**020HYDES3 Hydraulics 4 Cr.**

This course focuses on steady-state and transient flows. Based on an in-depth approach to pressure losses, special attention is paid to the design of simple and complex networks. The safety of networks is approached by the study of transient regimes and the sizing of adequate protections. Extended network analysis is undertaken by studying pumps and turbines.
**Prerequisite:** Fluid Mechanics (020MEFES1) or Fluid Mechanics 1 (020MF1ES1).

**020SSHES5 Hydraulic Servo Systems 4 Cr.**

This course covers the fundamentals of modeling and control of hydraulic servosystems. It provides theoretical background and practical techniques for the modeling, identification and control of hydraulic servosystems. Classical and advanced control algorithms are discussed. The use of MATLAB/Simulink and other programming languages will be an integral part in this course.
**Prerequisites:** Fluid Mechanics (020MEFES1) or Fluid Mechanics 1 (020MF1ES1) and Linear Control (020AULES2).

**020INDES2 Innovation and Design Thinking 2 Cr.**

This course is designed to cultivate a creative mindset and the practices essential for driving innovation. Students will explore the nature of creativity and the sources of groundbreaking ideas. The course emphasizes that fostering the belief in one's creative potential is the first step toward becoming an innovative thinker and leader. It also covers strategies for enhancing creative confidence and empowering others to adopt this mindset. Additionally, students will be introduced to the design thinking process, a proven methodology for systematic innovation. The course guides students through each stage of design thinking, from identifying needs and building empathy to generating insights, prototyping, and experimenting. Ultimately, the course focuses on cultivating an innovative mindset within professional environments and learning how to inspire and lead others in the pursuit of creative solutions.

**020IMEES1 Introduction to Electric Machines 4 Cr.**

Topics covered include: Magnetic materials and circuits - Three-phase regimes - Constitution, modeling and operation in steady state of the DC machine - Concept of rotating field - Constitution, equivalent diagrams and operation in steady state of the asynchronous machine and the synchronous machine.
**Prerequisite:** Electromagnetism (020EMENI3 or 020EMECI3).

**020AULES2 Linear Control 6 Cr.**

This course introduces important basic concepts in the analysis and design of control systems. It is divided into two parts. The first covers transient and steady-state response analysis of 1st and 2nd order linear systems, as well as frequency-response analysis using Bode, Nyquist and Nichols diagrams. It is followed by an introduction to closed-loop versus open-loop control systems leading to a stability analysis. The second part covers the analysis and design of linear control systems using different types of controllers. The design of such controllers is presented using frequency-response methods, analytical calculations, and experimental techniques. The whole is validated with exercises and workshops using MATLAB/Simulink, as well as a set of lab experiments leading to the design and test of a linear control system.
**Corequisites:** Analog Electronics (020ELAES1) or Prerequisite: Electronics (020ELCES1).

**020CM1ES3 Machine Design 1 4 Cr.**

This course covers fundamental mechanical design topics, such as static and fatigue failure theories, analysis of shafts, bearings and gears. In addition to fatigue failure criteria and S-N diagrams, it also covers surface failure, contact stresses, and static and fatigue stress concentrations. Students will learn to design the common elements of the machines which are studied by emphasizing their behavior under static and dynamic loads. The elements concerned in this course are represented by the transmission shaft, the keys and the couplings, the bearings and lubrication, and the spur gears.
**Prerequisites:** Strength of Materials (020RDMES1) or Strength of Materials 1 (020RM1ES2), Mechanical Systems (020SMEES1).

**020CM2ES4 Machine Design 2 4 Cr.**

This course is a continuation of Machine Design 1. Students will further develop their skills in designing and sizing mechanical components in machines, including helical, bevel, and worm gears, as well as brakes, clutches, flywheels, and flexible mechanical elements. The course also covers the design of tension, compression, and torsion springs, screws and fasteners, and welds. Additionally, students will be introduced to planetary gear trains and differential transmissions. The course emphasizes the study of mechanical components in relation to static and dynamic loads, as well as vibration phenomena.
**Prerequisites:** Machine Design 1 (020CM1ES3) and Mechanical Vibrations (020VMEES2) or Vibrations (020VIBES2).

**020MLRES4 Machine Learning 4 Cr.**

Machine learning (ML) is a subfield of Artificial intelligence. It is the science of making the machine learn by examples. The goal of ML is to make a computer that can learn from examples autonomously. The main research topics in ML include Computer Vision (CV), Natural Language Processing (NLP) and precision medicine for personalized treatments. The main goal of this course is to acquire a basic understanding of ML algorithms as well as hands-on ML engineering experience with regards to its application to realistic datasets through Python implementations that make use of state-of-the-art libraries such as Scikit-learn, Tensorflow and Keras.

**020MNGES4 Management 4 Cr.**

This course is a study of management theories, emphasizing the management functions of planning, decision-making, organizing, leading, and controlling.

**020PF1ES3 Manufacturing Processes 1 4 Cr.**

This course covers the main manufacturing processes used in the industry for different types of materials (metal, glass, plastics, rubber, composite materials, ceramics). It explains the concept of manufacturing in its large sense: the factory organization and design, the selection of processing operations and the production systems. The covered topics include the study of phase diagrams for different types of metal alloys, a global description of raw materials, and the operations used for their extraction and preparation (for metals, ceramics, polymers, and composites). In addition, the course introduces the material removal processes. It details the different operations made by a lathe, the basics of CNC machines and the G-code programming language for milling and turning processes.
**Prerequisite:** Computer Assisted Drawing (020DAMNI4 or 020DAMCI4).

**020PF2ES4 Manufacturing Processes 2 4 Cr.**

This course covers the main manufacturing processes used in the industry for different types of materials (metal, glass, plastics, rubber, composites, ceramics). It explains the techniques applied during the preparation of a product, from the fabrication of the primary parts to the finishing of the final assembled product. In addition to the "material removal processes" explained in the "Manufacturing Processes 1" course, the covered topics include: solidification processes (casting, molding …), particulate processing, deformation of metals and plastics, and assembly operations (welding, over molding, threading...) Also, the course describes some advanced processes and technologies such as waterjet cutting, laser cutting, layer-design, 3D printing and nanotechnologies.
**Prerequisite:** Manufacturing Processes 1 (020PF1ES3).

**020SMEES1 Mechanical Systems 6 Cr.**

This course allows students to establish the link between solid kinematics and mechanical construction. It covers the modeling and resolution of problems relating to mechanisms made of non-deformable/rigid bodies: bar-linkages and associated kinematics, kinematic diagram, parameterization, analysis of operation, determination of equations of motion (positions, speeds and accelerations), calculation of the forces applied to the parts and the generated and dissipated mechanical energies. It also introduces students to the fundamentals and principles of multi-bar connections, gears and cams. Modeling of several bar systems on SolidWorks will be carried out to study and visualize the movements of the mechanisms.
**Prerequisites:** Computer Assisted Drawing (020DAMCI4 or 020DAMNI4), Mechanics 2 (020MC2CI3 or 020MC2NI3).

**020VMEES2 Mechanical Vibrations 4 Cr.**

This course covers the vibrations of one-dimensional systems (1 Degree of Freedom), including undamped free oscillations, undamped forced oscillations, free damped oscillations, forced damped oscillations, stability, resonance, and systems with multiple degrees of freedom, with a focus on mechanical engineering applications and examples. Students will learn how to model a system and analyze its vibrational behavior. Linear systems with multiple degrees of freedom are solved using the mode superposition and modal analysis methods. The course also introduces non-linear systems, resolution through iterative methods, and vibration suppression techniques.
**Prerequisite:** Mechanics 2 (020MC2CI3 or 020MC2NI3).

**020MMCES4 Mechanics of Composite Materials 4 Cr.**

This course focuses on anisotropic elasticity and laminate theory, the analysis of various members of composite materials, energy methods, failure theories, and micromechanics. It also introduces materials and fabrication processes.
**Prerequisites:** Introduction to Materials Science (020ISMNI2 or 020ISMCI2) and Strength of Materials (020RDMES1) or Strength of Materials 1 (020RM1ES2).

**020MMIES5 Mechatronics and Intelligent Machines 4 Cr.**

This course offers a comprehensive exploration of mechatronics and intelligent machines, emphasizing sensors, actuators, system modeling, computer simulation, information processing, perception, cognition, planning, control, and system design. Students will gain practical knowledge through hands-on projects and applications.
**Prerequisite:** Linear Control (020AULES2).

**020MEMES5 Micro-Electro-Mechanical Systems 4 Cr.**

Topics covered include: sensors, sensor noise and sensor fusion; actuators; system models and automated computer simulation; information, perception, and cognition; planning and control; architectures, design, and development.
**Prerequisite:** Sensors and instrumentation (020CEIES3).

**020CTMES4 Modern Control 4 Cr.**

Topics covered include: Modeling a multi-variable system, interpretation, and linearization. Response and matrix transfer. Realization in controllability, observability, and Jordan forms. Controllability, and its properties, partial controllability. Observability and its criteria. Minimum implementation, stabilization, and detection. Directions of

the poles and zeros, simplification. Pole placement control, error integration, and observers. Optimal quadratic control (LQG): introduction, Riccati equation, Kalman filter, validity conditions. Guided mini project: modeling, design, and simulation.
**Prerequisite:** Linear control (020AULES2).

**020PRMES4 Multidisciplinary Project 6 Cr.**

This project brings together students from different programs and/or options where each student participates in the execution of a task related to their field. It aims to provide hands-on design experience, strengthen their analysis capacity, and develop their communication skills and teamwork ability. In this project, students must apply the knowledge acquired throughout their academic years of study and provide a final product that went through all stages of design, modeling, analysis, testing and evaluation. A final report and an oral presentation are the main deliverables of the project.

**020MFNES5 Numerical Fluid Mechanics CFD 4 Cr.**

Computational fluid dynamics (CFD) is a technology based on a fast and reliable calculation methodology for solving complex fluid flow and heat transfer problems. This course introduces the fundamentals and practical technical applications of CFD. Although it provides an overview of some of the fundamental mathematical equations governing fluid flow and heat transfer phenomena, it emphasizes the application of the knowledge gained in the practical use of commercial CFD codes. The course provides a detailed explanation of setting up, running and interpreting CFD model results for different ANSYS Fluent® case studies.
**Prerequisite:** Fluid Mechanics (020MEFES1) or Fluid Mechanics 1 (020MF1ES1).

**020MENES1 Numerical Methods 4 Cr.**

Topics covered include: Introduction to numerical calculation, error analysis and propagation, numerical software, interpolation and approximation, integration and differentiation, numerical solution to differential equations, finite difference method, matrices, resolution of linear systems, matrix decomposition, eigenvalues and eigenvectors, non-linear system of equations.
**Prerequisites:** [Linear Algebra (020ALNNI2) or Algebra 1 (020AL1CI2)] and [Differential Calculus (020CDFNI4) or Analysis 2 (020AN2CI3)].

**020PLBES4 Plumbing 4 Cr.**

This course provides a comprehensive understanding of plumbing applicable to various building structures. Students will adapt to international plumbing standards and comprehend their diverse applications. They will gain insight into French standards based on the DTU (Unifier Technical Document), American standards, including the NFPA "National Fire Protection Association" standard for firefighting. The key topics covered in this course include calculations for the dimensions of water distribution pipes, the selection of pipe types, calculations for the dimensions of evacuation pipes, sizing of booster pumps and their operational mechanisms, rainwater calculations, sizing of domestic hot water tanks, and understanding fire hoses for sprinkler systems and fire cabinets, including their operational principles.
**Prerequisite:** Hydraulics (020HYDES3).

**020PEDES5 Pollution, Environment and Sustainability 4 Cr.**

This course provides an overview of the causes and effects of global climate change, covering the basic science, projected impacts, and approaches to mitigation. It also includes methods for quantifying greenhouse gas emissions, controlling these emissions, and adapting to them, particularly in the HVAC/heating systems and building materials sectors. The course introduces the natural and anthropogenic carbon cycles, as well as carbon and climate concepts. Topics also cover the basics of green buildings, green materials for construction, material selection for sustainable design, green building certification, and methods for increasing energy efficiency in buildings. Additionally, the course includes the quantification of air, water, and soil pollution and their sources, sustainable wastewater treatment, solid waste management (sources and impacts), the zero-waste concept, and the 3R concept.

**020PENES4 Power Generation 4 Cr.**

The Power Generation course is designed to provide students with a deep insight into the various technologies and methodologies used to generate electrical power. It encompasses theoretical principles, practical applications, and the environmental considerations associated with power generation, especially the steam and gas power cycles. The course also covers the operating conditions of steam and gas cycles at design conditions and partial loads, as well as the economic and environmental aspects.
**Prerequisite:** Fluid Mechanics (020MEFES1) or Fluid Mechanics 1 (020MF1ES1).

**020RPEES5 Profitability of Energy Projects 4 Cr.**

This course enables students to understand, using economic tools, the profitability of an energy project. Topics covered include: Energy Efficiency Measures, Green Energy versus Gray Energy (Useful, Final, Secondary and Primary). Identification of the energy project and the financial package; Notions of Investment and technical and economic lifetimes; Annual Recipes and Earnings; Calculation of the Simple Return Time and return on investment; The energy return time; Simple cumulative profit in cash flow; Subsidy and financial incentives; Inflation; Cost of Energy Improvement; Cost of kWh in cash flow; Concept of discount and calculation of the discount rate; Present value and acquired value; Updated Return Time; Net Present Value (NPV); Internal Rate of Return (IRR); Annual Gains in Constant Annuity (AGCA); Economized Fuel Cost (EFC); Cost of kWh in cash flow and discounted (LCE); Integration of externalities into energy costs; Case studies.

**020GPRES2 Project Management 4 Cr.**

This course focuses on equipping students with the essential skills and techniques needed for successful project management, ensuring projects are completed on time, within budget, and to a high standard. It aims to teach students effective strategies for managing project budgets, schedules, and quality, while exposing them to a variety of practical tools and methodologies for overseeing projects they are currently working on or will be responsible for in the future.

**020SFRES5 Refrigeration Systems 4 Cr.**

Topics covered include: Industrial refrigeration - The refrigeration cycle - Mollier diagram - Volumetric compression - The components of the refrigeration machine: Compressor - Heat exchangers - Refrigerant - The design of a cold room - External quantities: Thermostat - Internal quantities: Regulators - Safety equipment - Defrosting.
**Prerequisite:** HVAC 1 (020CL1ES3).

**020ERNES5 Renewable Energy 6 Cr.**

This course offers a comprehensive exploration of the latest advancements in renewable energy technologies and their diverse applications. It aims to foster an understanding among students about the potentials and unique characteristics of renewable energies, particularly in the area of electricity generation. The course addresses key questions such as the nature of these energy resources, methods for their capture and transformation, and the various forms in which they can be utilized.
Throughout the program, students will explore specific topics, including the Principles of Solar Radiation (covering the solar spectrum, impact of geometry, and atmospheric attenuation), Solar Thermal and Solar Electric Photovoltaics (PV) with a focus on applications, PV System Components, Design, Selection & Sizing, as well as the Basics of Solar Energy System Engineering Economics. The program also explores the origin and power of wind, historical perspectives on wind turbines, Wind Energy System Components, Turbine Design & Control, Electrical Aspects of Wind Turbines, and the essentials of Wind Energy System Selection & Sizing, along with Wind Energy System Engineering Economics Basics. This comprehensive examination equips students with the knowledge and skills needed to navigate the complex landscape of renewable energies.

**020ROBES5 Robotics 4 Cr.**

This course aims to introduce some theoretical and practical fundamentals of robotics engineering related to electrical and mechanical domains. The concept of robotics is introduced starting from the sensors, actuator and closed loop representation, going through dynamics and kinematics equations, and reaching control of robots using linear, non-linear, and adaptive controllers. Topics covered include: Concepts of dynamic response related to vibration and motion planning. The principles of operation of various actuators, pneumatic, magnetic,

piezoelectric, linear, stepper, etc. Advanced feedback mechanisms using software executing in an embedded system. The concepts for real-time processor programming. Image processing and artificial intelligence. Neural networks and advanced controllers, along with their implementation using microcontrollers and/or software based (MATLAB, LabVIEW, etc.).

**020SPMES4 Selection and Properties of Materials 4 Cr.**

This course explains the relation between the properties of the materials and the selection procedure during engineering applications. It starts by reviewing the relation between the structure and the properties of a material, the mechanical behavior showing the different types of deformation behavior, and the failure types including fracture, fatigue, creep, and corrosion. Then, it lists the different properties of engineering materials and details their graphical presentation. Finally, it introduces the strategy of selection following manual and computer-aided methods. It also studies the selection procedure for applications having multiple constraints and conflicting objectives and treats several examples of simple and multiple selection problems. This course discusses the importance of the material-shape relation during selection operation.
**Prerequisite:** Strength of Materials (020RDMES1) or Strength of Materials 1 (020RM1ES2).

**020CEIES3 Sensors and Instrumentation 4 Cr.**

This course provides a general review of the main characteristics of a sensor (sensitivity, time response delay, measurement errors). Several types of sensors, such as optical sensors, temperature sensors, tachometric sensors, position and displacement sensors, force, weight and torque transducers, are described and studied in detail.
**Prerequisite:** Electronics (020ELCES1) or Digital Electronics (020ELNES2).

**020STAES1 Statistics 4 Cr.**

Topics covered include: Sampling distribution - Estimation by confidence intervals, estimation by maximum likelihood, and estimation by the method of moments - Hypothesis tests for the mean, the variance, the proportion, independence and fitting to a distribution - Simple and multiple linear regression - Non-parametric tests.
**Prerequisite:** Probability (020PRBNI4) or Algebra 3 (020AL3CI4).

**020RDMES1 Strength of Materials 6 Cr.**

This course covers the phenomena related to a deformable solid subjected to a system of external loads. It explores the fundamental hypotheses of beam theory and elasticity, geometric characteristics of sections, and types of stresses. Topics include generalized Hooke's law, axial stresses (mechanical, thermal stresses, and deformations), bending of beams and transverse shear (normal stresses, shear stresses, and displacements), and torsion of cylindrical members (stresses and deformations). The course also addresses bending moments and shear force diagrams, the state of stress in systems under combined loadings, and the analysis of stresses in the walls of thin-walled pressure vessels. Additionally, students will learn to calculate principal stresses, maximum in-plane shear stress, and absolute maximum shear stress. This course also introduces various static failure criteria for ductile and brittle materials. Practical applications include tensile tests on steel reinforcing bars, compressive tests on cylindrical concrete specimens, and twist tests on steel, brass, and copper specimens.
**Prerequisite:** Statics for Mechanical Engineering (020STMNI4 or 020STMCI4).

**020MOTES4 Thermal Engines 4 Cr.**

This course examines the fundamentals of the design and operation of internal combustion engines, focusing on fluid/thermal processes. The subjects covered include the analysis of the phenomena of aspiration, compression, combustion, expansion, expansion and formation of pollutants; heat transfer and friction phenomena; 2-stroke and 4-stroke engines, supercharges and performance characteristics; thermochemistry of air-fuel mixtures; social implications of motorization.
**Prerequisites:** General Chemistry (020CHGNI1 or 020CHGCI1) and Thermodynamics: Laws and Applications (020TPAES1) or Thermodynamics: Principles and Phase Change (020TPPES1).

**020TPAES1 Thermodynamics: Laws and Applications 6 Cr.**

This course is designed to provide students with a comprehensive understanding of the foundational principles of thermodynamics and their practical applications in engineering systems. It integrates theoretical concepts with

real-world scenarios, enabling students to apply thermodynamic principles to solve engineering problems and design efficient systems.
**Prerequisite:** Thermodynamics 1 (020TH1NI2 or 020TH1CI2).

**020TRBES3 Turbomachines 4 Cr.**

This course provides an overview of the latest technologies and developments in turbomachinery, as well as the diversity of their applications. It familiarizes students with the potential and specificities of the application of different turbomachines in the engineering world, from aviation to industrial machinery. In this course the following topics are covered: technology, operation, design and analysis of incompressible turbomachines such as centrifugal and axial flow pumps, impulse (Pelton) turbines and reaction turbines (Francis and Kaplan), as well as compressible flow turbomachines, such as: centrifugal and axial flow compressors, fans and blowers, axial and radial flow gas turbines, and steam turbines. Positive displacement pumps are also covered.

**020CM2ES4 Wheeled Robots 4 Cr.**

This course provides in-depth coverage of wheeled mobile robots. Topics covered include (i) nonholonomy and integrability of kinematics constraints; (ii) modelling: kinematics, dynamics, and state-space representation; (iii) nonlinear control strategies (open-loop and closed-loop), and (iv) simulation using the virtual wheeled mobile robots' laboratory. Four architectures are covered: differential-drive robot, Ackermann-based steering robot, Articulated-based steering robot, and mobile wheeled pendulum.

**020WRNES1 Work Ready Now 2 Cr.**

Topics covered include: Personal Development - Communication Skills - Job Seeking Skills - Work Behaviors.