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*Sustainable Development and Societal Responsibilities (SD/SR): : mentioned, : visible issues in the EU’s competences, : consideration of standards and regulations in the EU.

*Support to Innovation and Entrepreneurship: : discussed theme, : visible issues in the EU’s competences, : : : mastery of standards and regulations in the EU.
Learning Outcomes
On completing this teaching unit engineering students will be able to:
- Apply methods of group leadership and negotiation;
- Understand the factors that drive motivation;
- Use quality control tools in problem-solving;
- Determine the occupational hazards of a workstation and analyze the company's safety policy;
- Include work ethic to their trade;
- Understand the different steps of industrial patent design, writing and registration;
- Perform efficient industrial patent search and reading;
- Optimize their CV and interview skills so as to obtain an interesting internship.

Teaching Process (syllabus)

1. **Operational management**
   Giving a debriefing of management situations encountered during the 4th year work placement; creating management cases (Personal Evolution and Employability of the UNIT project); understanding the role and responsibilities of an engineer in company management; handling complicated cases and conflicts; conducting interviews and run meetings; negotiating purchases and sales methodically.

2. **Quality and safety management**
   Methodical problem-solving; using tools proper to lean management approach; including work ethic in management; preventing and tackling psychosocial risks; analyzing and diagnosing occupational hazards in order to control them.

3. **Patent of invention and industrial property**
   Understanding the existing links between innovation and industrial property; knowing patent registration criteria; being able to localize the different sections of a patent of invention when reading it; knowing how to make a patent database search to find relevant information.

4. **Recruitment**
   Writing a CV and cover letters that include the work experience gained in the 4th-year placement; planning a meeting for the next work placement; introducing and making oneself an attractive work candidate in an assessment interview role-play.

Assessment Mode: Written report on solving a management case (in teams), written report on a work ethic case. Mooc certificate on industrial property and invention patent, oral exam (recruitment simulation)

<table>
<thead>
<tr>
<th>Workload</th>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
<th>INDIVIDUAL WORK</th>
<th>PROJECT WORK</th>
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Proportion of the TU in English: 🌐🌐🌐 SD/CR: 🌐🌐🌐 Innovation: 🌐🌐🌐
On completing this teaching unit engineering students will be able to:

- Get organized, plan and run a stand independently upon an intercultural exhibition in English;
- Introduce and defend (team work) the research conducted on the intercultural topic of their choosing.
- Intercultural fair organization and installation
- Autonomous team work
- Regular follow-up meetings
- Debates and oral presentations
- TOEIC training (for those whose score is below 785)

Assessment Mode: 1 written exam, 1 timed oral presentation, 1 professional interview, intercultural fair participation

Proportion of the TU in English: 4/4
SD/CR: 4
Innovation: ✤
On completing this teaching unit engineering students will be able to conceive a digital system and:
- To perform a functional analysis according to the specifications;
- To perform Algorithm-Architecture Matching;
- To apply a design methodology (V-cycle);
- To implement a compliant solution.

Maps design
- Timing, interfacing
- Electromagnetic compatibility (EMC)
- Technological constraints: die bonding, system-on-chip (SOC), bare chips, 3D, MEMS

Processors
- Architecture of ARM processors: cache levels, pipeline, RISC architecture, DMA,DSP coprocessor, floating point vs fixed point
- Understanding the C/ compilation link, linkers, analysis of the generated code

FPGA/VHDL
- Hard and soft IP processors
- Synchronous and asynchronous logic
- VHDL / C co-design
- Verification, test vectors, model validation (test bench)

Assessment Mode: 1 prerequisite assessment, one assessment for each topic, 2 short projects

Workload

<table>
<thead>
<tr>
<th>LECTURES</th>
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<th>INDIVIDUAL WORK</th>
<th>PROJECT WORK</th>
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Student workload: 131h15

Proportion of the TU in English: SD/CR: 💫💫💫 Innovation:
On completing this teaching unit engineering students will be able to:

- Express a signal processing problem in mathematical form;
- Choose a resolution method for the problem;
- Implement the appropriate digital signal processing method.

- Mastering the mathematics for handling and characterizing signals and noise
- Formulating a digital signal processing problem
- Mastering sampling theorems
- Applying detection and estimation theory to practical cases

- Digital filtering
  - Being able to characterize an analog-to-digital converter
  - Being able to select and implement a filter on a dedicated hardware or software architecture
  - Knowing how to optimize the implantation of a digital filter
  - Being able to implement polyphase filtering
  - Mastering the principles of multirate filtering and filter banks

- Spectral analysis
  - Being able to program a non parametric Fourier approach (periodogram) or parametric one (AR)
  - Knowing how to choose and parameterize a spectral analysis method
  - Knowing how to code and analyze time-frequency or wavelet decompositions

- Invited lecture
  Speech processing, telecommunication

- Real-time processing on dedicated card
  - Multichannel real-time acquisition
  - Real-time filtering

**Assessment Mode:** Continuous assessment

**Workload**

<table>
<thead>
<tr>
<th>Lectures</th>
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<th>Classes</th>
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<th>Project Work</th>
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</table>

Student workload: 120h

Proportion of the TU in English: SD/CR: Innovation:
On completing this teaching unit engineering students will be able to:
- Create an industrial plasma source;
- Select and use the most relevant diagnostic to characterize an industrial plasma;
- Model plasmas operating in equilibrium or non-equilibrium regimes;
- Understand and use optical and spectroscopic diagnostics.

Teaching Process (syllabus)
1. Plasma properties
   - Introducing plasmas and their main properties
   - Mastering fundamental plasma phenomena
   - Mastering different electrical discharges: continuous, radio frequency and microwave discharges

2. Reactors and diagnostics
   - Understanding the structure and operating of reactors
   - Using and implementing different diagnostic tools and methods

3. Atomic and molecular physics, spectroscopy
   - Experimental spectroscopy
   - Defining atomic and molecular structures. Identifying energy levels in L-S, j-j and intermediate couplings. Using energy diagrams to detect emission lines
   - Analyzing atomic and molecular spectra by optical spectroscopy
   - Diagnosing gases and plasmas by active and passive spectroscopy (absorption, Laser Induced Fluorescence, etc.)

4. Labs
   - These tasks allow students to put acquired theoretical knowledge into practice.
   - A short-project – carried out during the whole semester – allows students to consider how to design and create a plasma reactor dedicated to a pre-defined industrial application.

Assessment Mode: At least 4 exams, homework assignments, individual work and oral presentations

Workload
<table>
<thead>
<tr>
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Student workload: 132h30

Proportion of the TU in English: ℝℝ SDL/CR: 🥀 Innovation: 🥀
On completing this teaching unit, engineering students will be able to:

- Describe the main reaction mechanisms (discharge physics and chemical kinetics) and hydrodynamic properties involved in plasmas working in equilibrium or non-equilibrium regimes;
- Perform electrical and chemical diagnoses on plasma reactors;
- Create, get familiar with, and optimize a plasma reactor for surface processing (micro- and nano-technological and biomedical applications) and effluent processing;
- Characterize and analyze material surfaces after plasma processing.

### Plasma Processing

#### Learning Outcomes

On completing this teaching unit, engineering students will be able to:

- Describe the main reaction mechanisms (discharge physics and chemical kinetics) and hydrodynamic properties involved in plasmas working in equilibrium or non-equilibrium regimes;
- Perform electrical and chemical diagnoses on plasma reactors;
- Create, get familiar with, and optimize a plasma reactor for surface processing (micro- and nano-technological and biomedical applications) and effluent processing;
- Characterize and analyze material surfaces after plasma processing.

#### Teaching Process (syllabus)

### Plasma chemistry and process engineering

- Mastering process engineering to build reactors. Commanding plasma reactors used for ozone production, pollution control (gases, liquids, surfaces) and biological and health processes (medical plasma)
- Designing a plasma reactor

### Thin film plasma processes

- Mastering plasma deposition techniques (cathode sputtering, PECVD, etc.) and etching techniques (silicon compounds, III-V materials, metals, etc.)
- Understanding plasma implantation processes for semi-conductor doping, plasma cleaning processes and dusty plasmas

### Plasma numerical simulation

- Mastering the basics of plasma numerical simulation through a fluid approach of mechanics of fluids, thermal science, electromagnetism and electrical discharge chemistry thanks to COMSOL Multiphysics® professional software

### Surface analysis

- Knowing techniques for the surface characterization of materials
- Analyzing surface composition (by XPS, AES, RBS, NRA) and determining their structural and microstructural morphology (TEM, XRD)

### Plasma experimentations

- Setting up, operating and diagnosing different types of discharges: ozone generation in DBD reactors, plasma diagnosis in a TCP discharge, etching, impulse discharge for nitrogen laser.

#### Assessment Mode

Exams, homework assignments, tests, lab assessments, oral presentations

### Workload

<table>
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<tr>
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Student workload: 130h

#### Proportion of the TU in English:

- R&D
- SD/CR: 🌟🌟🌟
- Innovation:
On completing this teaching unit engineering students will be able to:

- Carry out a software simulation to optimize an optical solution;
- Design useful media for information transfer, light transport and measurement;
- Define a relevant spectroscopic analysis protocol.

**Teaching Process (syllabus)**

**Optical simulation**
- Mastering simulation tools to optimize lighting optical solutions

**Applied optics**
- Knowing components dedicated to optical communications: fiber optics and sensors, amplifiers, laser diodes
- Knowing certain optical metrology techniques

**Technological innovations**
- Exploring innovative industrial applications through lectures by professionals from the industrial field /CNRS/CEA.

**Atomic and molecular physics, spectroscopy (in common with Plasma Sources TU)**
- Defining atomic and molecular structures
- Analyzing atomic and molecular spectra by optical spectroscopy techniques
- Diagnosing gases or plasmas by active and passive spectroscopy methods
- Using optical characterization tools

**Labs**
- Planar waveguides (integrated optics)
- Wavelength-division multiplexing
- Optical fibers and amplifiers (EDFA)
- Fiber optic sensors

**Assessment Mode**: 1 exam, lab assessments, reports

**Workload**

<table>
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Student workload: 123h15
### Laser Processing

**Learning Outcomes**

On completing this teaching unit engineering students will be able to:

- Select the most suitable laser for the intended application;
- Define the requirements and specifications to implement the laser process;
- Select the optical components and design the optical set-up to propagate the laser beam;
- Define the operating conditions to perform the process;
- Define the metrology devices necessary to controlling the process;
- Select the techniques of surface characterization with regard to the expected micro structural data to control the efficiency of the process.

**Teaching Process (syllabus)**

**Surface analyses (in common with IT TU)**

- Knowing principles and applications of analytical tools for the characterization of surface materials most commonly used in R&D: TEM, XPS, AES, RBS, NRA, ERDA, XRD
- Selecting the most suitable technique(s) with regard to the issue at hand
- Apply these techniques to the study of laser modified materials and surfaces

**Laser-Matter interaction and processing**

- Defining a laser beam: parameters (fluence, focal spot), beam shaping, beam transportation
- Knowing the components used in anisotropic and non linear optics
- Knowing the different regimes of laser-matter interactions
- Knowing phase transformation likely to occur in a given material
- Knowing industrial laser processing: cutting, welding, marking, laser shock, cleaning, drilling
- Knowing laser treatment surface modes: micro/nanostructuration, nitriding, carburetion, hardening, controlled ablation (polymer)

**Laser metrology and simulation methods**

**Labs**

- LIF, Laser N2, laser cleaning, spectroscopy

**Assessment Mode:** At least 2 exams, projects, homework assignments

### Workload

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<th>LECTURES</th>
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**Student workload:** 120h

**Proportion of the TU in English:** SD/CR: Innovation:
### Electronic and Optical Eco-technologies

#### 9VE03

**Ambient Computing**

**Supervisor:** Rémy LECONGE

**ECTS:** 12

**Semester:** 9

### Learning Outcomes

On completing this teaching unit engineering students will be able to:

- Write well-structured, robust and secure programs;
- Master parallel architectures and programming;
- Build user-friendly visual programs (using 2D or 3D graphics).

### Teaching process (syllabus)

#### Programming

- Designing advanced programs in C++
- Using Linux operating system

#### Computer graphics

- Understanding the hardware and software architectures for parallel computing
- Writing GPU-based programs
- Designing user-friendly interfaces
- Using the common libraries to generate and visualize 2D and 3D graphics

#### Software design

- Understanding and applying design and software quality methods
- Implementing software testing procedures

### Assessment Mode: Continuous assessment

### Workload

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**Student workload:** 120h

**Proportion of the TU in English:**

**SD/CR:**

**Innovation:**
Electronic and Optical Eco-technologies  

**Operative Imaging**

**Supervisor:** Rachid JENNANE

**ECTS:** 12

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### Learning Outcomes

On completing this teaching unit engineering students will be able to:

- Master the theoretical and practical aspects of image processing methods;
- Develop relevant approaches to validate the implemented imaging and vision techniques;
- Merge information from different sensors and make decisions.

### Teaching Process (syllabus)

#### Image analysis

Choosing the relevant software to solve the problem at hand; knowing how to segment an image; solving an ill-posed problem by inverse methods; detecting contours by deformable models; recognizing shapes in an image; classifying objects in image databases; embedding information into a digital image by watermarking; synthesizing textured images

#### Video processing

Exploiting visual perception, exploiting visual salience, tracking a target in a video sequence; modeling camera angles and camera displacement; constructing a panorama from a mosaic of images; exploiting augmented reality; reconstructing 3D objects by tomography

#### Testing, control and validation

Defining quality criteria; performing a multivariate analysis (ACP) and a dimensionality reduction; carrying out statistical analyses of the data under R

#### Data fusion

Merging data by fuzzy logic and belief functions; designing a virtual immersion system; embedding image processing; mapping images; processing colored images; processing data for knowledge retrieval

### Assessment Mode

Several marks for lectures and lab work. Marks for reports on individual work (independence, regularity, attendance, curiosity, interest, etc.)

### Workload

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</table>

Student workload: 120h

**Proportion of the TU in English:** 

**SD/CR:**

**Innovation:**
On completing this teaching unit engineering students will be able to:

- Set up or test a system, or develop a process following industrial quality control standards; equal importance will be given to project management methodology (drawing up the specifications, time management and scheduling of tasks) and to achievement of the project itself.

During eight continuous weeks, students, working either singly or in pairs, will carry out an industrial project consisting in:

- Building, testing, developing or optimizing an industrial process or software system in accordance with precise specifications previously defined by the scientific supervisor or project tutor in collaboration with the laboratory or company which submitted the project;
- Offer goals and a work plan for possible successors;
- This project is also backed up by language tutoring in English.

In the course of the project, students are supervised by their scientific supervisor or project tutor whom they must meet at least once a week to report on the completed work and actions to implement.

At the end of the project session, an oral presentation must be planned and a written report handed out to the tutor.

Assessment Mode: Oral presentations, project report, language tutoring, work accomplished and attitude during the project
<table>
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*Sustainable Development and Societal Responsibilities (SD/SR) : 🌅: mentioned, 🌄: visible issues in the EU’s competences, 🌅🌄: consideration of standards and regulations in the EU.

*Support to Innovation and Entrepreneurship : 🌅: discussed theme, 🌄: visible issues in the EU’s competences, 🌅🌄: mastery of standards and regulations in the EU.
On completing this teaching unit engineering students will be able to:

- Apply methods of group leadership and negotiation;
- Understand the factors that drive motivation;
- Use quality control tools in problem-solving;
- Determine the occupational hazards of a workstation and analyze the company's safety policy;
- Include work ethic to their trade;
- Understand the different steps of industrial patent design, writing and registration;
- Perform efficient industrial patent search and reading;
- Optimize their CV and interview skills so as to obtain an interesting internship.

Teaching Process (syllabus)

2. **Operational management**
   - Giving a debriefing of management situations encountered during the 4th year work placement; creating management cases (Personal Evolution and Employability of the UNIT project); understanding the role and responsibilities of an engineer in company management; handling complicated cases and conflicts; conducting interviews and run meetings; negotiating purchases and sales methodically.

5. **Quality and safety management**
   - Methodical problem-solving; using tools proper to lean management approach; including work ethic in management; preventing and tackling psychosocial risks; analyzing and diagnosing occupational hazards in order to control them.

6. **Patent of invention and industrial property**
   - Understanding the existing links between innovation and industrial property; knowing patent registration criteria; being able to localize the different sections of a patent of invention when reading it; knowing how to make a patent database search to find relevant information.

7. **Recruitment**
   - Writing a CV and cover letters that include the work experience gained in the 4th-year placement; planning a meeting for the next work placement; introducing and making oneself an attractive work candidate in an assessment interview role-play.

Assessment Mode: Written report on solving a management case (in teams), written report on a work ethic case. Mooc certificate on industrial property and invention patent, oral exam (recruitment simulation)

<table>
<thead>
<tr>
<th>Workload</th>
<th>Lectures</th>
<th>Lectures / Classes</th>
<th>Classes</th>
<th>Labs</th>
<th>Individual Work</th>
<th>Project Work</th>
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Student workload: 45h

Proportion of the TU in English: 🌍🌍🌍

SD/CR: 🌍🌍🌍

Innovation: 🌍🌍🌍
Learning Outcomes
On completing this teaching unit engineering students will be able to:
- Get organized, plan and run a stand independently upon an intercultural exhibition in English;
- Introduce and defend (team work) the research conducted on the intercultural topic of their choosing.

Teaching Process (syllabus)
- Intercultural fair organization and installation
- Autonomous team work
- Regular follow-up meetings
- Debates and oral presentations
- TOEIC training (for those whose score is below 785)

Assessment Mode: 1 written exam, 1 timed oral presentation, 1 professional interview, intercultural fair participation

<table>
<thead>
<tr>
<th>Workload</th>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
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<th>INDIVIDUAL WORK</th>
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<td>27h30</td>
<td>26h15</td>
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</table>

Proportion of the TU in English: ☑️ ☑️ ☑️
SD/CR: Innovation:
Civil Engineering and Environment

Learning Outcomes
On completing this teaching unit engineering students will be able to:

- Acquire, understand and use impact assessments;
- Understand and apply the Town Planning Code for land-use planning;
- Apply and comply with French and European waste management legislation;
- Analyze and select a waste management scenario.

Teaching Process (syllabus)

Legislation and tools
- Town Planning Code and land-use planning
- Procurement contracts legislation
- Life-cycle analysis (indicators, carbon footprint)
- ICPE/SEVESO directives
- General impact assessment (noise/water/air/dust/biodiversity)

Waste management
- Municipal and industrial waste management: nomenclature, statutory texts – collection / sorting and use of waste as material – incineration and dry residue management – ultimate waste storage centers – asbestos waste management
- Radioactive waste management: nomenclature, statutory texts – processing and storage
- Site visit: waste storage centre, materials recovery facility (clinker maturation), composting facility
- Case-study

Assessment Mode: Summary reports and reports

Workload

<table>
<thead>
<tr>
<th>LECTURES</th>
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</tbody>
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Student workload: 57h30

Proportion of the TU in English: SD/CR: 🌐🌐🌐 Innovation:
Structure Design and Sizing

Civil and Geo-environmental Engineering  
9CD12  
Semester 9  

Supervisor: Hamidréza RAMEZANI  
ECTS: 7

### Learning Outcomes
On completing this teaching unit engineering students will be able to:

- Know the behavior of metallic and mixed structures, calculate mechanical stresses, determine the dimensions of the structure and check its stability;
- Analyze wooden structures, calculate mechanical stresses and determine the dimensions of the wooden structure according to Eurocode 5;
- Analyze documents and technical drawings to understand structures and buildings as well as urban design.

### Teaching Process (syllabus)

#### Metallic and mixed structures (in French)
- Basic principle (Eurocodes).
- Design principle (Eurocodes).
- Member design (cross-sectional strength).
- Flexural members.
- Compression members.
- Design of the joints (welding and bolts).
- Joints and stress transmission.
- Check designs.
- Fatigue and failure of metallic structures.

#### Wooden structure calculation (in English)
- Wood and building materials.
- Introduction to Eurocodes.
- Dimensioning of the flexural members.
- Dimensioning of flexural and compression members.
- Dimensioning of glued laminated members.
- Dimensioning of composite members and wood sections.
- Dimensioning of wooden built-up columns.
- Dimensioning of wooden joints and sections.
- Technology of wood.

### Architecture and urban design
- Technical and financial management of construction sites.
- Urban planning and building law.
- Setting up of property transactions.
- Organization of building companies.
- Construction site logistics.

### Assessment Mode
- 1 exam on metallic and mixed structures, calculation of wood structures and a short project + 1 exam on architecture and urban design

### Workload

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<tr>
<th>LECTURES</th>
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</table>

Student workload: 92h30

### Proportion of the TU in English:
- 1
- 1
- 0
- 0

### Innovation:
- 0

SD/CR: 🌟🌟🌟
### Learning Outcomes
On completing this teaching unit engineering students will be able to:
- Plan a construction site;
- Manage a construction site financially;
- Plan construction for a specific project;
- Manage human resources according to the construction scheduling;
- Manage materials and equipment;
- Study the economic aspect of construction;
- Assess risks, comply with safety regulations;
- Read and analyze project requirements and documents;
- Read construction drawings and analyze their structure;
- Dimension the geometry of elements of a given structure;
- Study the rehabilitation of a building according to seismic and thermal regulation; suggest reinforcement for a given structure.

### Teaching Process (syllabus)
- Analyzing tender enquiries
- Identifying a building operation boundaries and interfaces
- Identifying construction modes and organizational methods used to plan a construction site
- Assessing environmental impact
- Calculating material quantities (quantity surveying)
- Introducing different technical constraints and suggestion of technical and economic variants
- Managing an actual project and calculation of structures in implementation phases (project teaching)
- Dimensioning the elements of a structure made of prestressed reinforced concrete in a metallic structure in both average and accidental (seism) situations, application of earthquake-resistant building regulation

### Assessment Mode
A report and oral defense for each design office project; an exam on construction sites

### Workload
<table>
<thead>
<tr>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
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</table>

Student workload: 70h

### Proportion of the TU in English: SD/CR: Innovation:
On completing this teaching unit engineering students will be able to:

- Identify the signs of degradation and understand materials weathering mechanisms (concrete, stone, wood);
- Find building sustainable solutions (building waste, bio-sourced insulation materials, organic concrete);
- Monitor degradation of buildings, recommend repair solutions;
- Understand the behavior of mechanic structures (wind, paraseismic factors) and rupture mechanisms.

Teaching Process (syllabus)

- Materials and structures in civil engineering: general properties
- Material and structural ageing: weathering mechanisms
- Inspection and control: auscultation, sensors, detection, means of remediation
- Remediation: legislation, restoration procedures
- Sustainable development aid: improving sustainability, respect for the environment

Assessment Mode: Several lesson tests, 1 exam

<table>
<thead>
<tr>
<th>Workload</th>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
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Proportion of the TU in English: SD/CR: Innovation:
On completing this teaching unit engineering students will be able to:

- Identify pollutants in a polluted soil and measure the degree of pollution;
- Know pollution control and remediation methods (Learning Outcome 3).

**Teaching Process (syllabus)**

**Polluted site management method**
- Typology of pollution, regulations and hazards, stakeholders, inventory and database

**Diagnosing pollution**
- Geochemistry of pollutants in soils and aquifers, impact of pollution, methodological tools

**Measuring and predicting pollution**
- Sampling, sampling techniques, identifying the dominant parameters, in situ measurements, methods of analysis

**Physical and biological pollution control, remediation of polluted sites**

**Case studies**
- Mercury, crop protection products, acid mining drainage, petroleum, etc.

**Assessment Mode:** Exam, visit report

**Workload**

<table>
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<tr>
<th>LECTURES</th>
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Student workload: 45h

**Proportion of the TU in English:** SD/CR: 🌟🌟🌟 Innovation:
On completing this teaching unit engineering students will be able to:

- Know the main natural processes involved in natural water geochemistry;
- Know the consequences of contamination in an aquatic environment;
- Model geochemical reactions in aquatic environments;
- Use PHREEQC software;
- Know the processes, sectors, equipment and industrial plants used for domestic, rainwater and industrial wastewater treatment, and for monitoring the quality of water resources;
- Apply this knowledge to the dimensioning, installation, implementation and evaluation of the operation of water and wastewater treatment processes in industry, in developed areas, in pollution controlled sites and in the natural environment.

Applied geochemistry for water treatment


Wastewater treatment and purification

Classroom lesson: water purification processes and sectors, rainwater and domestic wastewater purification, industrial wastewater treatment and purification.

Presentations on site: drinking water production plant (ultrafiltration, biological denitrification, iron and manganese removal, descaling by electrochemical processes, elimination of pesticides on granular activated carbon, etc.), industrial and urban wastewater treatment plants (activated sludge, membranes, macrophyte ponds, etc.), monitoring station for water resource quality surveillance and emergency controls, hydrogeological systems linked to the drinking water plants and wastewater treatment plants in the Val d’Orléans and the Gâtinais (Loiret county).

Assessment Mode: PHREEQC geochemistry short-project report (homework assignment, 25 %), case study report on water treatment and purification (homework assignment, 50 %), thematic interdisciplinary report on on-site presentations about water treatment and purification (homework assignment, 25 %).

Workload

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Student workload : 55h

Proportion of the TU in English: 🍿_RDONLY  SD/CR: 🐠:textbooks 🏕️:leisure Innovation: 🌟
### Learning Outcomes

On completing this teaching unit, engineering students will be able to:

- Implement main hydrogeologic methods in the field (flow, piezometric map, pumping test, tracing);
- Characterize and model water and pollutants transfer in surface and underground hydrologic systems;
- Proportion devices for active management of aquifers and pollution mitigation.

### Teaching Process (syllabus)

- Notions of hydrological cycle, residence time and groundwater storage volume
- Interaction between reservoirs, mixing, tools for active resource management using hydrodynamic modeling (Modflow software)
- Mass transfer mechanisms, at pore level and at the macroscopic level, pollutant reactivity
- Flow measurement via exploration of the velocity field exploration and chemical gauging
- Drawing up a piezometric map and delimitation of the system
- Well-production test to characterize the hydrodynamic properties
- Artificial tracing (sizing, installation and implementation, spectrofluorimetric detection, concentration-time curve)
- Synthesis and data interpretation in the karstic environment of the Val d’Orléans, report writing

### Assessment Mode:

Synthesis report further to a project

### Workload

<table>
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<tr>
<th>Workload</th>
<th>Lectures</th>
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### Proportion of the TU in English:

- SD/CR: 🌟🌟
- Innovation:
Field Geology and Drilling

Learning Outcomes
On completing this teaching unit engineering students will be able to:
- Practice data acquisition systems on instrumented sites, structure data and assess the effects of climate and environmental parameters on greenhouse gases (CO2/CH4) produced by a peat land;
- Understand the main techniques of underground drilling, their implementation conditions and their ranges of application in civil engineering for water and geothermal exploration.

Teaching Process (syllabus)
Drilling
- Water well: churn drilling, down-hole drill rig and rotary drilling, borehole, drilling fluids, equipment, grouting and pressure losses in drilling and development works
- Geothermal drilling: energy context of geothermal power, designing geothermal plants using heat pumps and geothermal drilling

Biogeochemistry and hydrogeology on instrumented site
- At OSUC instrumented site, peat land of La Guette (Sologne), flow measurements of CO2 and CH4 (in situ tropospheric infrared spectrometer – SPIRIT), environmental variables (soil temperature, ground water level, water physico-chemistry, root depth, leaf-area index, light level), water samples and lab analysis (COD)

Assessment Mode: Report (field) and exams (drilling)

Workload

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Student workload: 35h

Proportion of the TU in English: 45%  SD/CR: 🌻 Solar Hot

Innovation: 🧪
### Learning Outcomes

On completing this teaching unit engineering students will be able to:

- Master the nomenclature of classified facilities for the protection of the environment (ICPE) and the contents of a submission for a license to operate;
- Apply the methodology to conduct an environmental impact assessment;
- Take risks into account (especially floods) in land-use planning.

### Teaching Process (syllabus)

#### Environmental impacts

- Impact assessments strictly speaking on the themes of field geology and water management and a specific topic such as public easement or dusts
- Hazard assessment
- Simulation of the activity of an environmental engineering design department: study in groups of a report on the operation of a quarry

#### Risks

- Risk management chain: uncertainty/issues, security/protection, forecasting, damage repair
- Flood risk
- Study of dangers and crisis management
- Principles and methods for the prioritization of water resource vulnerability and GIS application of the indicator-based approach

### Assessment Mode

Group report on a case study about environmental impacts, exam on risk management

### Workload

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<th>LECTURES</th>
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Student workload: 27h30

### Proportion of the TU in English: SD/CR:

Innovation:
Civil and Geo-environmental Engineering  
9TP12  
Semester 9

Urban Design

Supervisor: Jean-Marie SCHAFF  
ECTS: 9

Learning Outcomes

On completing this teaching unit engineering students will be able to:

- Design load-bearing structures and foundations for small engineering works according to site data and the work specifications;
- Understand the transportation issues at stake in urban environments, the main modes of transportation and the associated infrastructures as well as their planning and design techniques;
- Design and compute a pavement structure according to specifications (traffic), given supporting soil and climate environment;
- Design and dimension the rainwater and wastewater sewer system including associated storage basins;
- Draw a linear infrastructure (road, railroad) using Mensura software;
- Understand the acoustic factors at stake in infrastructure, calculate the noise level produced, design and dimension a noise control system such as an acoustical barrier.

Teaching Process (syllabus)

Engineering works
Specifications, site and regulation data. Load-bearing structure design: foundation design and calculation. Overview of the main types of bridge design.

Transport infrastructures

Pavement dimensioning

Sewer systems design and dimensioning
Revision on hydraulics and Mensura software. Case studies on actual rainwater / wastewater projects using Mensura.

Road alignment
“Alignments” drawing on Mensura. Implementation of an alignment project on Mensura.

Road acoustics

Assessment Mode: Engineering works: model of a bridge; transportation infrastructures: an MCQ on each topic; pavement dimensioning, sewer systems and road alignments: several short-projects; road acoustics: 1 exam

Workload

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<th>LECTURES</th>
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Student workload: 113h45

Proportion of the TU in English: SD/CR: 3

Innovation:
Civil and Geo-environmental Engineering  
9TP13  
Semester 9

Public Works

Learning Outcomes
On completing this teaching unit engineering students will be able to:

- Define the schedule of quantities for a construction site; optimize its tasks and organization. Through productivity, they will be able to estimate its duration, cost and environmental impact limited to greenhouse gases. They will know how to handle impact between works and rescue archeology;
- Choose and optimize quantities of materials necessary to construction sites among which stones, soils, pipes, coated materials... Acquired knowledge about these hydrocarbon coated materials and their bonding agents will allow students to optimize their compositions;
- Master main geophysics tests, their implementation conditions and their fields of applicability in civil engineering;
- Dimension armed concrete structure commonly used in public works.

Teaching Process (syllabus)
This TU is the logical consequence of “Road Construction” 8TP08. Many implementation projects allow students to deepen their knowledge and skills while giving them the opportunity to get prepared for their future professional position:

- construction sites, study of economical variants or solutions with a limited environmental impact,
- concomitance with an archeological dig,
- use of natural stones,
- implementation of networks (wastewater, rainwater, multitube, etc.),
- specific coated materials (HiMA, draining and aeronautical asphaltic concrete, etc.),
- road recycling,
- structural design for buildings in armed concrete,
- geophysical measurements tackled through numerous labs.

Assessment Mode: Classes assessments, reports, individual assessments and synthesis reports

Workload

<table>
<thead>
<tr>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
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<td>33,45 h</td>
<td>36,15 h</td>
<td>26,30 h</td>
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Student workload: 110 h

Proportion of the TU in English: SD/CR: 🌟🌟🌟 Innovation: 🌟
Civil Engineering Project

Learning Outcomes
On completing this teaching unit engineering students will be able to:

- Handle a project to answer a company’s, a design office’s or a laboratory’s real issue — in relation to civil engineering or environment — while complying with the requirements;
- Manage and plan a project until communication of results;
- Implement or optimize an industrial process, a calculation or characterization method;
- Master project management methods.

Teaching Process (syllabus)
- Presenting the project and defining objectives with a member of the teaching staff in charge of suggesting the requirements and supervising the student working alone or in pair
- Analyzing documents and considering the project constraints and specifications
- Defining a work schedule
- Implementing the different steps
- Communicating the results with an oral viva
- Linguistics follow-up done by an English teacher

Assessment Mode: A written report and a scientific oral defense in French, a poster and an oral defense in English

<table>
<thead>
<tr>
<th>Workload</th>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
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Proportion of the TU in English: 

SD/CR: 

Innovation:
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</table>

*Sustainable Development and Societal Responsibilities [SD/SR]: 🌱: mentioned, 🌱🌱: visible issues in the EU's competences, 🌱🌱🌱: consideration of standards and regulations in the EU.

*Support to Innovation and Entrepreneurship: 🌱: discussed theme, 🌱🌱: visible issues in the EU's competences, 🌱🌱🌱: mastery of standards and regulations in the EU.
Learning Outcomes
On completing this teaching unit engineering students will be able to:

- Apply methods of group leadership and negotiation;
- Understand the factors that drive motivation;
- Use quality control tools in problem-solving;
- Determine the occupational hazards of a workstation and analyze the company’s safety policy;
- Include work ethic to their trade;
- Understand the different steps of industrial patent design, writing and registration;
- Perform efficient industrial patent search and reading;
- Optimize their CV and interview skills so as to obtain an interesting internship.

Teaching Process (syllabus)

3. Operational management
   - Giving a debriefing of management situations encountered during the 4th year work placement; creating management cases (Personal Evolution and Employability of the UNIT project); understanding the role and responsibilities of an engineer in company management; handling complicated cases and conflicts; conducting interviews and run meetings; negotiating purchases and sales methodically.

8. Quality and safety management
   - Methodical problem-solving; using tools proper to lean management approach; including work ethic in management; preventing and tackling psychosocial risks; analyzing and diagnosing occupational hazards in order to control them.

9. Patent of invention and industrial property
   - Understanding the existing links between innovation and industrial property; knowing patent registration criteria; being able to localize the different sections of a patent of invention when reading it; knowing how to make a patent database search to find relevant information.

10. Recruitment
    - Writing a CV and cover letters that include the work experience gained in the 4th-year placement; planning a meeting for the next work placement; introducing and making oneself an attractive work candidate in an assessment interview role-play.

Assessment Mode: Written report on solving a management case (in teams), written report on a work ethic case. Mooc certificate on industrial property and invention patent, oral exam (recruitment simulation)

Workload

<table>
<thead>
<tr>
<th>Lectures</th>
<th>Lectures/Classes</th>
<th>Classes</th>
<th>Labs</th>
<th>Individual Work</th>
<th>Project Work</th>
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Student workload: 45h

Proportion of the TU in English: ☑️
SD/CR: ☑️
Innovation: ☑️
On completing this teaching unit engineering students will be able to:

- Get organized, plan and run a stand independently upon an intercultural exhibition in English;
- Introduce and defend (team work) the research conducted on the intercultural topic of their choosing.

### Learning Outcomes

### Teaching Process (syllabus)

- Intercultural fair organization and installation
- Autonomous team work
- Regular follow-up meetings
- Debates and oral presentations
- TOEIC training (for those whose score is below 785)

### Assessment Mode:

1 written exam, 1 timed oral presentation, 1 professional interview, intercultural fair participation

### Workload

<table>
<thead>
<tr>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
<th>INDIVIDUAL WORK</th>
<th>PROJECT WORK</th>
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</table>

Student workload: 27h30

Proportion of the TU in English: 🇫🇷 🇧🇷 🇦🇷

SD/CR:  🔧

Innovation: ✍️
Learning Outcomes
On completing this teaching unit engineering students will be able to:

- Address a complex mechatronics system by using fundamental concepts of articulated robots and the associated automation devices;
- Use tools and techniques to simulate, plan and control the motion of industrial and mobile robots;
- Analyze and process an image.

Teaching Process (syllabus)

Theory
- General introduction to robotics
- Functional description of a robot
- Motion analysis and control for robot manipulation: direct geometrical model, inverse dynamic model, direct and inverse kinematic models
- Motion analysis and control for mobile robots: direct and inverse kinematic models
- Robotics languages and programming: methods, principles and limitations
- Robot vision: image acquisition system; basic image processing

Practicals
Five lab sessions will provide practice for the topics studied during classes and lectures:

- Dynamic and kinematic simulation of a 6-axis robot
- Simulation of a virtual environment for a mobile robot
- Generation of paths for mobile robots
- Shape recognition and assembly
- Developing an obstacle avoidance strategy

Assessment Mode: 3 assignments and matching oral defenses (to choose from a list) + lab reports

Workload

<table>
<thead>
<tr>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
<th>INDIVIDUAL WORK</th>
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</table>

Student workload: 50h

Proportion of the TU in English: SD/CR: Innovation:
On completing this teaching unit engineering students will be able to:

- Model, parameterize and analyze mechatronics systems: dynamic behavior, assembly and geometric dimensioning of deformable elements, kinematic modeling of a mechanism; assess energetic reversibility levels in electromechanical chains and describe them with SySML tool;
- Write a measurement protocol while adapting to the compatible equipment available;
- Analyze the performances and modeling limitations of a system from measurements. Write result summary sheets.

**Teaching Process (syllabus)**

- Behavior of bolted assemblies: dimensioning and study of the boundary layer separation of screw assemblies
- Diagnosing the malfunctioning of a measurement bench for the assembly of prestressed bearings: proof of malfunction, systemic search for causes and proposal for corrective actions
- Dynamic modeling of a simulator: detecting modeling discrepancies between the actual system and its representation in a dynamic simulator (ADAMS)
- Kinematic modeling of a robot gripper: study and diagnostic research of welding defects caused by the gripper
- Reversibility of electrical drive control motorizations: a complete motorization chain using a DC synchronous self-driven motor illustrates these features by associating torque control and speed control
- Electrical aspects of open-loop positioning using a stepper motor: full-step and half-step control modes, static, dynamic and mechanical aspects, boundary of the mechanical plane
- Energetic and SySML approach in a start-up/rolling/braking cycle of a starter-alternator benchmark test

**Assessment Mode**: Memo for each session and an oral presentation

**Workload**

<table>
<thead>
<tr>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
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</table>

Student workload: 25h

**Proportion of the TU in English:**

SD/CR: 🏆

Innovation:
On completing this teaching unit engineering students will be able to:

- Become active members of a project team in order to exercise their skills; apply their specific expertise to the design of a mechatronics system;
- Take into account the constraints of the different disciplines in mechatronics and communicate with 'experts' in each discipline;
- Apply a mechatronics design approach to concurrent engineering in CAD (Catia, Matlab Simulink, etc.);
- Apply project management concepts to a mechatronics design study, plan and manage meetings, assess project risks;
- Use a Product Lifecycle Management (PLM) tool to determine how the project will be conducted and grasp product/project/program concepts.

This teaching unit adopts a project-based approach. The industrial study of the design of a mechatronics system will give students the opportunity to:

- Create and organize project workgroups, determine and manage the project on a macroscopic level using SySML tool;
- Implement a project management approach using the PLM tool;
- Carry out a complete product design project, from the initial formulation and validation of the need to finding suppliers and producing detailed plans (GPS functional dimensioning).

The project will be carried out in the framework of numerical concurrent engineering using CAD and numerical simulation tools studied in previous TU (Mathlab/Simulink, Catia, Adams, CVI, etc.).

Project reports will be written and oral presentations given both in French and English.

All learners will act as experts in their discipline as well as monitor and contribute to the work carried out by other members in the team. Additional skills input will be provided in class and wrap-up sessions in consistency with the project progress.

At the end of the teaching unit each group will give an oral presentation and produce a written report detailing the accomplished design.

Assessment Mode: Reports and defense, involvement in the activities of the project group, final validation before a jury including industrialists.

<table>
<thead>
<tr>
<th>Workload</th>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
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</tbody>
</table>
On completing this teaching unit engineering students will be able to:

- Model a process and summarize a control in state space;
- Compensate for the lack of measurements by synthesizing a software sensor (estimator);
- Synthesize an optimal control law.

Teaching Process (syllabus)

- Modeling processes as state space representations. Study of system properties (controllability, observability, stability). Synthesis of state feedback control laws (pole placement, decoupling control, linearizing control). State observers (soft sensor)
- Constraint-free dynamic optimal control, optimal control under an equality constraint, linear quadratic control (LQC), robustness of a linear quadratic regulator (LQR), optimal control by state feedback with stability degree. Optimal control with observer. Various applications will be studied in class using the following tools: Matlab, Simulink and Control toolbox
- Applying the knowledge acquired in automatic control classes concerning systems identification and control to several real processes:
  - Exhaust gas recirculation valves in internal combustion engines
  - Gas throttle valve of a gasoline engine
  - Train overhead cable

Assessment Mode: Graded lab report and lab oral defense, graded tutorial report and exam

Workload

<table>
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<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
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Student workload: 50h

Proportion of the TU in English: SD/CR: Innovation:
On completing this teaching unit engineering students will be able to:

- Optimize cylindrical gear geometry in industrial reducers; study the influence of different parameters on their dimensioning;
- Select a material that meets targeted performances and is compliant with environmental standards;
- Analyze a product life-cycle (LCA), interpret the different indicators and assess their impact. Take this analysis into account in the design phase (V model);
- Dimension and choose the means of lubrication so as to minimize energy losses;
- Use functional tolerancing in order to optimize functional and energy performances;
- Apply an eco-design approach to an industrial project (in the framework of TU 9MC05).

Degradation of gear teeth with use; fatigue damage. Dimensioning of the preliminary design and verification of the load-carrying capacity of a component in compliance with the ISO633 standard. Introduction to and use of Kiss-Soft and Kiss-sys software. Optimizing a component dimensioning. Two conferences: power transmissions to gear

Teaching Process (syllabus)

1. Complements on power transmissions per gear
   Degradation of gear teeth with use; fatigue damage. Dimensioning of the preliminary design and verification of the load-carrying capacity of a component in compliance with the ISO633 standard. Introduction to and use of Kiss-Soft and Kiss-sys software. Optimizing a component dimensioning. Two conferences: power transmissions to gear

2. Product Lifecycle Assessment (LCA)
   Selection of materials using the Ashby method: general method, building models in accordance with the bill of specifications. Analysis of a product life-cycle in accordance with ISO 14040 standards; strategy and different phases of the LCA; positioning of LCA in a project; analysis and interpretation of the indicators; assessment of indicators impact; analysis and assessment of design strategies. Introduction to “product assessment” tools (ADEME), CES EduPack software and applications

3. Lubrication
   Different lubrication modes (hydrodynamic, hydrostatic, elastohydrodynamic); permanent, critical and lubricating regimes; lubrication dimensioning and performances

4. Functional tolerancing as a tool increasing energy gain
   Functional tolerancing as a tool guaranteeing the performances listed in the bill of specifications (reliability, life span); converting the geometric criteria of the specifications into tolerancing conditions; strategy to reduce costs of production

Assessment Mode: Continuous assessment, homework assignments and exams

Workload

<table>
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<tr>
<th>Lectures</th>
<th>Lectures /Classes</th>
<th>Classes</th>
<th>Labs</th>
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Student workload: 50h

Proportion of the TU in English: ☑️

SD/CR: ☑️

Innovation:
On completing this teaching unit engineering students will be able to:

- Understand the mechanical behavior of composite structures.

**Teaching Process (syllabus)**

- Orthotropic behavior of plies
- Calculating the stiffness matrices of laminates
- Theory of laminates and strength criteria
- Transverse shear. Edge effects. Delaminating
- Dimensioning composite structures. Thermo-hygro-mechanical analytical calculation of a simple geometry

**Assessment Mode:** Continuous assessment

**Workload**

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<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
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**Proportion of the TU in English:** 2

**SD/CR:** Innovation:
Innovation in Conception and Materials 9MM07  Semester 9

Nonlinear Behavior of Materials

Supervisor: Alain GASSER  ECTS: 2

Learning Outcomes
On completing this teaching unit engineering students will be able to:

- Recognize nonlinear behavior types and choose an associated law;
- Identify nonlinear behavior law coefficients;
- Use the most common nonlinear behavior law.

Teaching Process (syllabus)

- Thermodynamic approach for law design in material behaviors
- Study of different nonlinear behaviors: nonlinear elasticity, plasticity, damage, failure, viscoelasticity, hyperelasticity
- Identification of nonlinear behavior law coefficients
- Examples of the use made of these laws to solve mechanical problems in continuum mechanic

Assessment Mode: Exams and homework assignments

Workload

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<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
<th>INDIVIDUAL WORK</th>
<th>PROJECT WORK</th>
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</table>

Student workload: 27h30

Proportion of the TU in English: ☑  SD/CR:  Innovation:
### Learning Outcomes
On completing this teaching unit engineering students will be able to:

- Master the processes used to engineer different classes of materials, apart from glass, polymers and composites;
- Know the main properties of metal use;
- Know the different types of material surface processing.

### Teaching Process (syllabus)

1. **Ceramic engineering**
   - Methods to produce ceramics, practical case study: silicate ceramics, refractory ceramics, techniques
   - High-temperature heat treatment of ceramics. Characterization

2. **Metalworking**
   - Industrial metalworking processes. Thermodynamics of metallurgical reactions
   - Global study of a metallurgical reactor

3. **Surface engineering**
   - Different types of surface processing. Deposition/coating/thin films processes
   - Deposition processes: general properties, implementation and industrial examples
   - Wet process: molten medium, electro deposition, chemical deposition, chemical conversion (phosphatising, anodizing)
   - Dry process: PVD depositions (thermal evaporation, cathode sputtering, molecular beam epitaxy) and CVD depositions (PECVD, MOCVD)

### Assessment Mode:
Continuous assessment, short-projects, a written report and oral presentations

### Workload

<table>
<thead>
<tr>
<th></th>
<th>Lectures</th>
<th>Lectures / Classes</th>
<th>Classes</th>
<th>Labs</th>
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</table>

**Proportion of the TU in English:**

- SD/CR: 🌍
- Innovation: 🌍
On completing this teaching unit engineering students will be able to:

- Understand how a component or part of a structure is produced, what raw materials and forming techniques are used;
- Understand how an engineer selects and masters ceramic materials to withstand complex multiphysics stresses (thermal-mechanical-chemical couplings);
- Understand “multiphysics coupling modeling” concepts and apply them to the field of advanced ceramics.

**Teaching Process (syllabus)**

1. **Lectures**
   - Fundamental principles in thermodynamics of irreversible processes
   - Conservation equations, state laws, laws of evolution
   - Numerical solution to transport equations, time/space coupling
   - Implementing behavior laws
   - Heat transport mechanisms in ceramics
   - Complex and coupled degradation: thermomechanical and thermochemical degradations

2. **Applications (finite elements code Abaqus)**
   - Thermomechanics in stationary and transient regimes, thermo-hydro-mechanics (THM) in transient regime, thermoderlectricity

3. **Industrial case-studies**
   - Heat transfer and dimensioning of industrial facilities
   - Dimensioning ceramic work pieces (mechanical and thermomechanical aspects)
   - Selection criteria of materials to meet given stresses
   - Probability of failure of technical ceramics (SiAlON, nitrides)
   - Case-study: thermomechanics, corrosion, complex degradation: mechanisms, kinetics, technological choices

**Assessment Mode:** Homework assignment(s), 1 exam

**Workload**

<table>
<thead>
<tr>
<th>Lectures</th>
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<th>Classes</th>
<th>Labs</th>
<th>Individual Work</th>
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</table>

Student workload: 55h

**Proportion of the TU in English:** 🌍

**SD/CR:** 🌱

**Innovation:** 🌍
Learning Outcomes
On completing this teaching unit engineering students will be able to:
- Model and simulate structures comprising materials with different nonlinear behaviors (plasticity, hyperelasticity, viscoelasticity, etc.);
- Take geometric and contact non-linearities into account;
- Model and simulate structures under different types of loading (thermo-mechanical, vibrational, etc.).

Teaching Process (syllabus)
Simulation by finite element analysis of complex structures using ABAQUS
- Efficiency of finite elements
- Influence of geometric non-linearities (large displacements) on shells and beams
- Modeling material behavior (thermomechanical, elasto-plastic, hyperelastic, viscoelastic behavior)
- Modeling composite materials
- Application session in dynamics and vibrations (calculation of eigenmodes, dynamic stresses)
- Contact consideration. Simulation of buckling

Simulations of forming processes in implicit and explicit analysis
Introduction to crash simulation (fast dynamics)

Assessment Mode: Reports and calculations to hand in after each class

Workload
<table>
<thead>
<tr>
<th>LECTURES</th>
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<th>CLASSES</th>
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<th>INDIVIDUAL WORK</th>
<th>PROJECT WORK</th>
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</table>

Student workload: 35h

Proportion of the TU in English: SD/CR: Innovation:
On completing this teaching unit engineering students will be able to:

- Become active members of a project team in order to apply their skills and specific expertise;
- Take into account the constraints of the different fields (design, simulation, production);
- Use a Product Lifecycle Management (PLM) tool to run the project;
- Define a bill of specifications;
- Optimize an actual structure according to the constraints listed in a given bill of specifications.

**Teaching Process (syllabus)**

- **Project : « Bridge in composite materials »**
- Design and testing of a small-scale bridge made of composite materials, in response to the competition organized by Sampe. Sampe (Society for the Advancement of Material and Process Engineering) is an international organization whose members are industrialists working in Materials and Process engineering.
- Finite element dimensioning; manufacturing and processes; dimensioning and architecture of bridges; experimental testing

**Assessment Mode:** Reports and oral defenses, involvement in a project group, examination in front of a panel of teachers

**Workload**

<table>
<thead>
<tr>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
<th>INDIVIDUAL WORK</th>
<th>PROJECT WORK</th>
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Student workload : 32h

**Proportion of the TU in English:**

<table>
<thead>
<tr>
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<th>Innovation:</th>
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<tbody>
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<td>📑</td>
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</table>
On completing this teaching unit engineering students will be able to:

- Have a comprehensive understanding of modeling heat transfer and thermomechanical behavior of materials;
- Calculate actual industrial cases (automotive, aerospace, etc.);
- Understand metallurgical concepts necessary for engineering and forming advanced alloys, their properties and limitations of use;
- Tackle practical applications (energy, automotive and aeronautical engineering, mechanical construction, civil engineering, etc.)

### Teaching Process (syllabus)

#### 1. Transfer modeling
- Study of the different Nastran cards
- Patran/Nastran interface
- Space and enclosure radiations, high temperature heat exchanges
- Modeling thermomechanical problems
- Industrial case-studies
- Comparison with a study using an infrared camera

#### 2. Properties of use and stresses of metal alloys
- Recap of the fundamentals in metallurgy
- Introduction to metal alloys
- Metal alloys under extreme conditions
- Industrial case studies: engineering, characteristics, properties of use (cryogenic alloys; Fe, Ni and Fe, Ni, Cr alloys (stainless steels); precious alloys (Au, Ag, Cu); modern steels (IFS, DWI, HLE, TRIP, Steel cord)
- Superalloys, refractory metals, ceramic-metal (Cermet)

### Assessment Mode: Written report, oral presentations

### Workload

<table>
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<tr>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
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Student workload: 55h

### Proportion of the TU in English:

- SD/CR: 🌟
- Innovation: 🌟
On completing this teaching unit engineering students will be able to:

- Write a bill of specifications based on a requirement analysis
- Set up functional and technological specifications for a project
- Set project milestones and provide deliverables
- Conduct a project

Teaching Process (syllabus)

1. Organization
   Students working in the framework of this teaching unit will be supervised by a scientific tutor. This is a “full-time” project starting in January and finishing in mid-March. In that instance, students will produce a written report, a poster in English and an oral defense.

2. Scientific content
   - Students will be offered a wide variety of project topics: feasibility study for a new concept, conception of a process for a dedicated application, broadening of theoretical knowledge, conduct an industrial study, etc.
   - In every instance, engineering students must show their ability to handle a project, to take initiatives, know of to task share (work as pairs) and to complete a technical study successfully within the allocated time.

Assessment Mode
Written report (final report and one for each stage of the project), oral defense, poster, project tutoring, language skills tutoring

Workload

<table>
<thead>
<tr>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
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Student workload: 172h

Proportion of the TU in English: 

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5th Year- Master 2- Spring Semester

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<th>SIE*</th>
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*Sustainable Development and Societal Responsibilities (SD/SR): ☑️: mentioned, ☑️☑️: visible issues in the EU’s competences, ☑️☑️☑️: consideration of standards and regulations in the EU.

*Support to Innovation and Entrepreneurship: ☑️: discussed theme, ☑️☑️: visible issues in the EU’s competences, ☑️☑️☑️: mastery of standards and regulations in the EU.
On completing this teaching unit engineering students will be able to:

- Apply methods of group leadership and negotiation;
- Understand the factors that drive motivation;
- Use quality control tools in problem-solving;
- Determine the occupational hazards of a workstation and analyze the company’s safety policy;
- Include work ethic to their trade;
- Understand the different steps of industrial patent design, writing and registration;
- Perform efficient industrial patent search and reading;
- Optimize their CV and interview skills so as to obtain an interesting internship.

**Teaching Process (syllabus)**

4. **Operational management**
   
   Giving a debriefing of management situations encountered during the 4th year work placement; creating management cases (Personal Evolution and Employability of the UNIT project); understanding the role and responsibilities of an engineer in company management; handling complicated cases and conflicts; conducting interviews and run meetings; negotiating purchases and sales methodically.

11. **Quality and safety management**
   
   Methodical problem-solving; using tools proper to lean management approach; including work ethic in management; preventing and tackling psychosocial risks; analyzing and diagnosing occupational hazards in order to control them.

12. **Patent of invention and industrial property**
   
   Understanding the existing links between innovation and industrial property; knowing patent registration criteria; being able to localize the different sections of a patent of invention when reading it; knowing how to make a patent database search to find relevant information.

13. **Recruitment**
   
   Writing a CV and cover letters that include the work experience gained in the 4th-year placement; planning a meeting for the next work placement; introducing and making oneself an attractive work candidate in an assessment interview role-play.

**Assessment Mode**: Written report on solving a management case (in teams), written report on a work ethic case. Mooc certificate on industrial property and invention patent, oral exam (recruitment simulation)

**Workload**

<table>
<thead>
<tr>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
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<th>PROJECT WORK</th>
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Student workload: 45h

**Proportion of the TU in English**: 🌐🌐🌐

**SD/CR**: 🌐🌐🌐

**Innovation**: 🌐🌐🌐
## Learning Outcomes

On completing this teaching unit engineering students will be able to:
- Get organized, plan and run a stand independently upon an intercultural exhibition in English;
- Introduce and defend (team work) the research conducted on the intercultural topic of their choosing.

## Teaching Process (syllabus)

- Intercultural fair organization and installation
- Autonomous team work
- Regular follow-up meetings
- Debates and oral presentations
- TOEIC training (for those whose score is below 785)

## Assessment Mode

1 written exam, 1 timed oral presentation, 1 professional interview, intercultural fair participation

## Workload

<table>
<thead>
<tr>
<th></th>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
<th>INDIVIDUAL WORK</th>
<th>PROJECT WORK</th>
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</table>

## Proportion of the TU in English:
- [ ]

## SD/CR:
- [ ]

## Innovation:
- [ ]
On completing this teaching unit engineering students will be able to:

- Describe, understand and analyze the physical phenomena occurring in turbulent flows;
- Use tools to process and analyze experimental and numerical results;
- Choose the correct level of description/modeling for digital simulation (MILES, LES, DES, RANS) depending on needs and available resources;
- Use the CFD ANSYS Fluent® software for RANS simulation in turbulent flows.

### Learning Outcomes

#### 1. Physical description and statistical analysis of turbulence
- Statistical tools: random variables, statistical moments and 1 or 2-point correlations, stochastic averaging, general theorems
- Physics of turbulence: Eulerian scales in space and time, Kolomogrov scales, Taylor’s hypothesis, homogeneous and isotropic turbulence, spectra, double-correlation dynamics, inertial law (K41 theory)
- Experimental approach: practical demonstration of measurement techniques in non-reactive flow (hot-wire, LDV, PIV)
- Signal and image processing: time and space averages, Fourier transform, time and space correlations, power of spectral densities. Implementation: LVD signal processing, hot-wire (3.45 hours lab), PIV image processing

#### 2. Operational modeling: 1-point closures (RANS)
- Recap and complements: Reynolds’ formalism, statistical equations in incompressible flow, closure issues
- RANS formalism in compressible flow: Favre averaging, Morkovin hypothesis
- Newtonian closure: 1-equation (Spalart-Allmaras) and 2-equation (k-ε, k-ω,...) models, wall laws

#### 3. Large Eddy Simulation
- Explicit subgrid filtering and modeling: physical and spectral space, generalized central moments, eddy viscosity models (Smagorinsky, Structure-Function model), scale similarity model (Bardina), Germano identity, dynamic models (Germano-Lilly)
- Implicit large-scale simulation: implicit filtering of a digital scheme, transfer function, dissipative and dispersive schemes, applications

#### 5. CFD applications with ANSYS Fluent® 15.0

### Teaching Process (syllabus)

**Assessment Mode:** 2 short written tests, homework assignment, lab reports in CDF and experimental lab reports

### Workload

<table>
<thead>
<tr>
<th>Workload</th>
<th>Lectures</th>
<th>Lectures/Classes</th>
<th>Classes</th>
<th>Labs</th>
<th>Individual Work</th>
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</table>

**Proportion of the TU in English:**

**SD/CR:**

**Innovation:**
On completing this teaching unit engineering students will be able to:

- Acquire the requisite knowledge to describe, understand and analyze turbulent combustion phenomena coming into play in industrial applications;
- Know the basic mechanisms determining the formation and reduction of pollutant emissions;
- Identify parameters influencing heat release and the formation of the main pollutants (soot, NOx) for applications such as internal combustion engines, thermal power plants (coal, gas, biofuels) and turbine engines. Know how to vary parameters to optimize the working of the energy system;
- Use CFD software to simulate a complex system;
- Acquire an overview of the tools allowing characterizing a reactive or non-reactive turbulent eddy flow (measurement and post-treatment means).

### Teaching Process (syllabus)

- Combustion chemistry (thermodynamics applied to chemistry, chemical kinetics)
- Self-ignition (theory, measurement methods, examples of detailed modeling)
- Premixed flames (flammability limit, flame stabilization, extinction parameters, propagation velocity, flame thickness, ...)
- Diffusion flames
- Combustion high-energy materials and explosives
- Formation of pollutants and post-processing systems
- Flame/turbulence interactions
- Models of turbulent combustion for premixed and diffusion flames
- Illustration of the phenomena of combustion and pollutant formation with recent technologies
- Introduction to tools allowing to characterize a reactive or non-reactive turbulent eddy flow (lab)
- Signal and image processing (digital tool Matlab)
- Introduction to CHEMKIN software (chemical kinetic)
- Application of notions tackled through 3D calculation codes (FLUENT and FIRE)

Many conferences given by industrial stakeholders and researchers will be planned on different topics.

### Assessment Mode:
At least 3 written tests or exams. 3 homework assignments using digital tools (1 with CHEMKIN and 2 with FLUENT)

### Workload

<table>
<thead>
<tr>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
<th>INDIVIDUAL WORK</th>
<th>PROJECT WORK</th>
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Student workload: 65h

<table>
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<tr>
<th>Proportion of the TU in English:</th>
<th>SD/CR:</th>
<th>Innovation:</th>
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</table>
On completing this teaching unit engineering students will be able to:

- Acquire the knowledge require to calculate, analyze and characterize the physical phenomena present in flows at speeds ranging from high subsonic to hypersonic;
- Master digital tools to predict these flows and understand the role of the mathematical properties of Euler’s equations (hyperbolicity, characteristics) in numerical shock-capture schemes (FVS, FDS). Review of the main schemes. Initiation into FORTRAN programming.

### Teaching Process (syllabus)

#### 1. Dynamics of high speed flows
- Recap of the 4th year course on thermodynamics, the Euler system, normal shocks
- 1D unsteady flows: characteristics, Riemann invariants, shock tube
- 2D steady flows: oblique shocks, interaction of shocks, Mach disc. Expansion fan, Prandtl-Meyer relation, linearized theory, characteristics, Cauchy problem
- ‘Cold’ hypersonic airflows: entropy layer, viscous interaction, similarity

#### 2. Numerical methods to solve Euler’s equations
- Recap on Euler 1D system: conservative, primitives and characteristic variables, transformation matrices, Riemann invariants
- Conservative schemes, first-order ‘upwind’ finite-volume schemes based on flux splitting (FVS) and approximate Riemann solvers (FDS)
- Second-order extension: MUSCL approach, TVD schemes and flow limiters

#### 3. Machine applications with FORTRAN language
- Linear convection: programming, management of boundary conditions
- Burgers’ equation: Riemann problem with compressive or expansive initial conditions
- Programming Lax-Friedrichs and CIR schemes with a constant time-step
- Application to the Sod shock tube problem with fixed boundary conditions. Management of boundary conditions: free non-reflective output, reflective closed boundaries, mixed conditions
- Programming the Roe scheme with Harten’s entropy fix, adaptive time-step with constant CFL and ordinary boundary conditions

#### 4. Autonomous supervised project

### Assessment Mode: 3 short written tests, exams, homework assignments

### Workload

<table>
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<tr>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
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</table>

Student workload: 65 h

Proportion of the TU in English: SD/CR: 🌍 Innovation: 🔄
On completing this teaching unit engineering students will be able to:

- Understand the physical and chemical processes taking place during combustion and during fuel injection in internal combustion engines. Use modeling to understand the reaction of a given engine to a change in one of its parameters;
- Construct a model of an internal combustion engine. Optimize the dimensioning and tuning of an engine under various constraints: performance, power, and pollutant emissions, using an engine model.

### Teaching Process (syllabus)

- **Combustion**: thermochemistry and kinetics applied to combustion. Self-ignition. Premixed flames, flammability limit, flame stabilization, extinction parameters and turbulent combustion. Diffusion flames. Two-phase combustion. Internal engine aerodynamics. Notions of preparation of the mixture, definition of the requirements for spark ignition and for self-ignition, combustion initiation and propagation (definition of the basic combustion speeds), pollutant formation. Definition of user drivability requirements in terms of fundamental data
- **Thermodynamic models**: classification into air models, single-zone models, two-zone models, multizone models. Models of combustion chamber wall losses. Limits of validity.
- **Combustion models**: semi-empirical model of Vibé, application to a controlled ignition engine. Extension of the model to compression ignition engines. Models for controlled ignition engines. Models for compression ignition engines (jet, vaporization, self-ignition delay, premixed phase and diffusion phase combustion models)
- **Fuel injection models**: filling/emptying model and 1D intake/exhaust gas dynamics model. Boundary conditions: open, closed, and partly open intake manifold, junctions. Heat losses and losses due to wall friction. Reconstruction of the filling curves
- **Turbocharging**: static and dynamic models of the turbocharger. Turbocharger performance and speed maps. Turbine/compressor adaptation. Pumping limit. Dynamics of the turbocharger, response time
- **Specific tools**: Matlab/Simulink, GTpower, Chemkin. Assembling engine models from component libraries, using the detailed models analyzed in this teaching unit

### Assessment Mode

3 reports

<table>
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<th>Workload</th>
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<td>PROJECT WORK</td>
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Student workload: 65h

Proportion of the TU in English: 🌐🌐🌐

SD/CR: 📝📝📝

Innovation: 📈 الخيال 📈
On completing this teaching unit engineering students will be able to:

- Master engine control systems, control strategies and the associated control devices (captors, actuators, controllers);
- Implement control strategies for internal combustion engines;
- Apply the knowledge acquired in class to the tuning and control of internal combustion engines on a test bench, an actuator bench or via simulation;
- Perform energy balance on a hybrid vehicle and generate an energy management law.

### Teaching Process (syllabus)

#### 1. Theory

- History of engine control: carburetor, mechanical injection
- State of the art: sensors, actuators, hardware and software implementation of the controller, strategies
- Spark ignition engine control: basic strategies (fuel enrichment, ignition advance), pollution control (fuel enrichment adjustment, catalyst, light-off, EGR), detecting knock, anti-knock strategies, idle, start, cold start, drivability
- Diesel engine control: basic strategies (quantity of injected fuel, smoke limit), multiple injection, homogeneous charge engines, idle, start, cold start, drivability
- Development methods
- Embedded networks
- Embedded models: intake manifold dynamics, turbochargers, fuel, friction
- Automatic control: PID control and advanced control
- Control based on physical or heuristic models, torque control
- Hybrid vehicles: definitions, issues, energy management (heuristic and optimal)

#### 2. Practice

- Tuning of an internal combustion engine: 3 labs, 2 of which on a real test bench
- Engine control: 3 labs, 1 of which on an actuator bench system and 1 on an engine bench
- Energy management in a hybrid vehicle: 1 lab on a roller bench

It should be noted that 2 labs will be conducted at John Deere in Saran.

This teaching unit also aims at raising awareness among engineering students regarding engine control and its tuning (engine mapping, PID control, advanced control).

### Assessment Mode

Lab reports, oral defense, homework assignments

### Workload

<table>
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<tr>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
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<td>46h15</td>
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Student workload: 69h
On completing this teaching unit engineering students will be able to:

- Identify professional elements in different technical and human fields related to chargé d'affaires engineers specialized in building and sustainable energies;
- Master different standards, classic and sustainable production means and production modes coordination. Suggest economical and innovative solutions respectful of the environment.

### Teaching Process (syllabus)

1. **Environmental standards, regulations and requirements**
   - Thermal control, very high quality sustainable architecture (THQE), para-public labels, Agenda XXI, project conduct with decision-makers (town halls, promoters, private companies...). Environmental footprint, embedded energy et LCA (Life Cycle Analysis)

2. **Thermal auditing and diagnostic**
   - Environmental audit, EPD (Energy Performance Diagnostic) and carbon balance. Needs identification (AMO) and implementation of eco-responsible improvements. Simple assessment models for suggested solutions

3. **Passive energetics**
   - Conventional and bio-sourced materials. Architecture, header captors, solar walls, etc.

4. **Digital models**
   - Homogenization theory, transitory regulation models (DF, EF, integrators)
   - Predictive approach and use plan management. Release, production and consumption grouping to achieve energy management

5. **Renewable energies**
   - How to invert primary and secondary production sources. Solar thermal energy, wind power, shallow or great depth geothermal energy. Collaboration between different production modes as a function of needs

6. **Heat exchangers**
   - Heat pumps, fin heat exchangers. Wood burners and forests sustainable management

### Assessment Mode

1 project conduct, 1 homework assignment: modeling and energies integration, 2 CC ENR exchangers

### Workload

<table>
<thead>
<tr>
<th>LECTURES</th>
<th>LECTURES /CLASSES</th>
<th>CLASSES</th>
<th>LABS</th>
<th>INDIVIDUAL WORK</th>
<th>PROJECT WORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>31h15</td>
<td>20h</td>
<td>10h</td>
<td>3h45</td>
<td>11h15</td>
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Student workload: 65h

### Proportion of the TU in English:
- [ ]
- [ ]
- [ ]

### SD/CR:
- [ ]
- [ ]

### Innovation:
- [ ]
On completing this teaching unit engineering students will be able to:

- Dimension an energy production system (combined cycle, steam power plants and boilers);
- Apply notions of security and nuclear safety.

### Learning Outcomes

**Energetic Systems**

**ECTS: 6**

**Supervisor:** Camille HESPEL

**Technologies for Energy, Aerospace Engineering and Motorization**: 9VS22  
**Semester 9**

### Teaching Process (syllabus)

**Energy production on the industrial scale**
- Nuclear power plants (principle, primary and secondary cycles, safety)
- Thermal power plants (functioning of a facility)
- District heating systems

**The different components in energy production**
- Steam generators
- Steam turbines
- Boilers (water circulation, furnace design)
- Exchangers

**Advanced thermodynamics**
- Study of water/steam cycles
- Enthalpy and Mollier diagrams
- Study of the combine cycle gas (general functioning, principles and applications)

**System optimization**
- Main controls (power, temperature, level)
- Cogeneration
- Case-study on thermoflow

**Geopolitics of energy**
- National, European and international regulation
- Alternative energies
- Short and long-term issues

### Assessment Mode

- 3 exams and a written report

### Workload

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<td>17h30</td>
<td>13h45</td>
<td>7h30</td>
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</table>

Student workload: 65h

### Proportion of the TU in English:

- SD/CR: 🌟🌟🌟
- Innovation:
On completing this teaching unit engineering students will be able to understand and describe the main physical phenomena concerning aeroacoustic (aerodynamically generated noise) and aeroelastic (coupling between aerodynamics and elastic deformations) aspects and their effects, in particular those associated with the unsteadiness of fluid flows and to carry out some simple modeling.

**Learning Outcomes**

On completing this teaching unit engineering students will be able to understand and describe the main physical phenomena concerning aeroacoustic (aerodynamically generated noise) and aeroelastic (coupling between aerodynamics and elastic deformations) aspects and their effects, in particular those associated with the unsteadiness of fluid flows and to carry out some simple modeling.

**Teaching Process (syllabus)**

1. **Aeroacoustics**

   General notions of aerodynamic noise, fields of application, sound propagation in flows in homogeneous media, calculation of the radiated noise, noise sources, interaction between flows and acoustics. Concrete examples of noise nuisances. Unsteady wave motion. Representative parameters of local noise motion. Intensity, noise level, noise sources. Propagation equation with and without flow. Theory to calculate aerodynamic noise (Lighthill’s analogy)

2. **Aeroelasticity**

   Using the classic and digital tools of steady and unsteady aerodynamics and of the mechanics of deformable solids, modeling, describe and analyze the main characteristics of the steady and dynamic behavior of deformable objects (airfoils, wings, rotors, etc.) subjected to the interaction between elastic, inertial and aerodynamic forces and which may lead to the phenomena of stationary aeroelastic divergence or unsteady flutter. Introduction to the problem of fluid-structure coupling. Recap on elasticity - strength of materials and aerodynamics. Steady aeroelasticity: formulation of the problem, analysis of the divergence of a wing with a large aspect ratio and of control surface reversal. Dynamic aeroelasticity: formulation of the problem; distinction between the different modes of aeroelastic coupling (resonance, flutter). Flutter in steady aerodynamics and application to a wing that is much more flexible in flexion than in torsion: aeroelastic stability and dynamic response using the model cross-section. Unsteady aerodynamic modeling of an airfoil and its effects on the previous results

**Assessment Mode:** Several written tests, exams and homework assignments in the course of the TU

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<tr>
<th>Workload</th>
<th>Lectures</th>
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<th>Labs</th>
<th>Individual Work</th>
<th>Project Work</th>
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**Proportion of the TU in English:**

**DDRS:**

**Innovation:**
### Project

**Learning Outcomes**

On completing this teaching unit engineering students will be able to:

- Conduct a study to solve an industrial or research issue using an engineering approach;
- Develop and consolidate disciplinary skills acquired during the three-year training;
- Set a bill of specifications and schedule tasks;
- Perform regular follow-up with the actors of the project, plan follow-up meetings;
- Work autonomously;
- Synthesize the progress made and present them in a written report and oral presentation.

**Teaching Process (syllabus)**

- Project and format selection (solo, duo or group work)
- Establishment of contact with the limited partner of the study (company or laboratory)
- Writing of the bill of specifications submitted to the limited partner for approval
- Task scheduling and follow-up meetings
- Identification of the tools and resources necessary to the project conduct
- Risk analysis and fallback solutions
- Technical realization of the study
- Update of the project follow-up and implementation of fallback solutions if required
- Delivery of a synthesis report
- Oral presentation of the results of the study

**Assessment Mode:** Report and oral defense

**Workload**

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**Student workload:** 172h

**Proportion of the TU in English:** 📘

**SD/CR:** 🌟

**Innovation:** 🌟