**ECOLE NATIONALE SUPERIEURE**
**D'ELECTRICITE ET DE MECANIQUE**
2, Avenue de la Forêt de Haye
54500 Vandoeuvre-lès-Nancy

**Academic year 2025-2026**
**Detailed curriculum 2025-2026 NRJ_FISA**

## Semester S5

| Code | Course Unit | ECTS | Code | Course | Coeff | *Teacher* | Vol | CM | TD | TP |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ? | Solid mechanics | 0,2 | *J.-F. Schmitt* | **36** | 16 | 8 | 12 |
| | | | 5JEPPN11 | The basics of thermodynamics | 0.2 | *G. Pernot* | **36** | 22 | 14 | 0 |
| | | | 5JEPPN12 | Tools for electricity | 0.2 | *T. Boileau* | **36** | 16 | 12 | 8 |
| | | | 5JEPPN13 | Electricity and Magnetism - Circuits | 0.2 | *F. Meibody* | **36** | 16 | 12 | 8 |
| 5JUPPN01 | Fundamental sciences | **10** | 5JEPPN14 | Signals and systems - modeling | 0.2 | *V. Louis-Dorr* | **36** | 19 | 7 | 10 |
| | | | 5JEPPN20 | Programming and algorithms | 0,4 | *?* | **36** | 11 | 10 | 15 |
| | | | 5JEPPN21 | Foundations of mathematics for engineers | 0,3 | *V. Lecuyer* | **49** | 20 | 29 | 0 |
| | | | 5JEPPN22 | Transformation & complex analysis | 0,3 | *V. Lecuyer* | **31** | 16 | 15 | 0 |
| 5JUPPN02 | Engineering Sciences 1 | **5** | 5JEPPN23 | Energy efficiency and sustainable development | pass/fail | *T. Boileau* | **6** | 6 | 0 | 0 |
| | | | 5JEPPN30 | English 1 | 0,3 | *S. Gallaire* | **24** | 0 | 24 | 0 |
| | | | 5JEPPN31 | second foreign language-1 English support | 0,3 | *S. Gallaire* | **24** | 0 | 24 | 0 |
| | | | 5JEPPN35 | Project management | 0,2 | *J.-C. Marpeau* | **10** | 0 | 0 | 10 |
| | | | 5JEPPN32 | Communication 1 | 0,2 | *A. Thimon* | **16** | 0 | 16 | 0 |
| | | | 5JEPPN33 | Workplace Safety 1 | pass/fail | *T. Boileau* | **8** | 8 | 0 | 0 |
| 5JUPPN03 | Humanities 1 | **5** | 5JEPPN34 | French language clearance 1 | pass/fail | *A. Quesada* | **1** | 0 | 1 | 0 |
| | | | | Technical competence | | | | | | |
| | | | | Methodological competence | | | | | | |
| | | | | Interpersonal skills | | | | | | |
| 5JUPPN04 | S5 Company | **10** | 5JPPN40 | Report 1A | | | | | | |

| EC ? | Solid mechanics | UE 5JUPPN01 Fundamental sciences | J.-F. Schmitt |
|---|---|---|---|

**Total hours : 36**
**Lecture hours : 16**
**Tutorials hours : 8**
**Practical/lab hours : 12**

## Objective

The objective of this EC is to develop models for structural design. These models, developed under simplifying assumptions based primarily on geometry, constitute the first level of structural design methods. Slender structures, the basic elements of mechanical engineering, are particularly addressed here.

## Skills acquired

To be able to ensure that with a minimum quantity of material, a structure made up of one or more beams meets the requirements of strength (the structure supports and transmits the external loads imposed on it), rigidity (the structure does not undergo excessive deformation when stressed), stability where applicable (buckling and lateral buckling are avoided). To be able to assess the state of stress and deformation of slender structures. On an experimental level, to become familiar with the different measurement techniques used in the mechanics of deformable solids.

## Prerequisites

Basic knowledge of solid mechanics and continuous media mechanics

## Assessment

Practical work reports to be submitted at the end of each 4-hour session. Continuous assessment: tests (3 to 4) lasting from 30 minutes to 1 hour throughout the lecture and tutorial sessions.

## Teaching program

Course: Main hypotheses (small disturbance hypothesis, Saint Venant principle, Navier-Bernouilli hypothesis) - Loads - Connections - Global equilibrium equations - Unstable, isostatic, externally hyperstatic structures - Internal forces - Identification of the type of stress - Equilibrium equations of an infinitesimal beam slice - Normal force - Plane reticulated systems - Bending moment - Pure bending - Simple bending - Case of straight beams in isostatic and externally hyperstatic bending - Torsion moment in the case of a straight beam with a solid or hollow circular section - Shear force - Energy theorems - Combined stresses - Bresse formulas - Calculation of externally or internally hyperstatic structures - Elastic limit criteria - Dimensioning. Tutorials: the tutorial sessions focus more specifically on the following points: Session 1: Statics of beam-type structures – Calculations of internal forces – Identification of the stress. Session 2: Slender structures working in tension/compression – Study of plane reticulated systems. Session 3: Study of the bending of straight beams with constant or variable section. Session 4: Calculations of beam-type structures in the case of combined hyperstatic stresses externally or internally. Application of fundamental theorems (energy theorems, Bresse formulas, etc.). Practical work: the practical sessions allow students to familiarize themselves with the measurement techniques used in the mechanics of deformable solids and to verify the validity of the main results established in class or of theoretical models developed from the course

| EC 5JEPPN1 | The basics of thermodynamics | UE 5JUPPN01 Fundamental sciences | G. Pernot |
|---|---|---|---|

**Total hours : 36**
**Lecture hours : 22**
**Tutorials hours : 14**
**Practical/lab hours : 0**

Objective

The EC of thermodynamics addresses the fundamental principles that govern the operation of energy devices. These principles are the basis of: the definition of the equilibrium conditions of matter, and therefore the conditions that allow its transformation, the conservation and conversion of energy, the determination of possible evolutions of systems and their performances

Skills acquired

Students will master the thermodynamic knowledge necessary for the study of energy systems. They will have the tools to tackle common problems (thermal machines, phase changes). They will have the basics of photovoltaic and thermoelectric conversion.

Prerequisites

none

Assessment

Continuous assessment (minimum 3 marks) in the form of written tests lasting ~ 30 to 45 minutes

Teaching program

lecture: definitions of thermodynamic quantities and processes energy exchanges: work / heat conservation of energy: first principle evolution of systems: second principle thermal machines changes of state of a pure body. energetic aspects of phase changes. evolution of systems: thermodynamic potentials open systems introduction to combustion thermoelectric conversion tutorial: first principle: study of a metal wire in traction second principle thermal machines phase changes thermodynamic potentials: free energy thermoelectricity

| EC 5JEPPN1 | Tools for electricity | UE 5JUPPN01 Fundamental sciences | T. Boileau |
|---|---|---|---|

**Total hours : 36**
**Lecture hours : 16**
**Tutorials hours : 12**
**Practical/lab hours : 8**

Objective

The objective of this module is to provide the theoretical and practical knowledge necessary for students to be able to follow the power electronics courses.

Skills acquired

Mastery of the study of electrical circuits in transient conditions. Mastery of the simulation of transient conditions using Matlab Simulink using the state equation. Mastery of the method of studying diode assemblies. Knowledge of the elementary notions of analog electronics (AOP), the notions of input impedance, output impedance

Prerequisites

Differential equations, differential systems. Kirchhoff's laws

Assessment

Assessment of practical work reports and written exams

Teaching program

lecture Transient regimes and modeling Matlab Simulink AOP diodes and AOP assemblies Transistors lab work Oscilloscope Differential amplification Class B and Class D amplifier

| | | | |
|---|---|---|---|
| ***EC 5JEPPN1*** | **Electricity and Magnetism - Circuits** | ***UE 5JUPPN01 Fundamental sciences*** | ***F. Meibody*** |

**Total hours : 36**
**Lecture hours : 16**
**Tutorials hours : 12**
**Practical/lab hours : 8**

Objective

This module provides the basics of external modeling of electrical systems. The objectives are: - To establish the equivalent electrical diagram of the system studied and to determine its main variables. - To master the methods for studying single-phase and three-phase circuits in steady sinusoidal mode. - To introduce magnetic circuits with simple topologies to study and model magnetically coupled inductances as well as single-phase and three-phase transformers.

Skills acquired

Model an electrical system by an equivalent circuit diagram using elements representing the physical phenomena observed in its components such as energy dissipation and storage. - Study single-phase and three-phase electrical systems in sinusoidal mode using equivalent circuits. - Model devices with magnetically coupled windings by magnetic circuits using permeance networks. - Model single-phase and three-phase transformers and determine their characteristics and performances

Prerequisites

Complex numbers, derivation and integration.

Assessment

Three tests (continuous assessments) assess theoretical knowledge on modeling and determining the performance of electrical systems in steady sinusoidal mode. In addition, experimental skills during practical work are also assessed by marking the reports produced on the identification of parameters of single-phase and three-phase transformer models and the measurement of their performance.

Teaching program

Single-phase and three-phase electrical systems (7h lecture, 4h tutorial): Model the production, transport, storage and conversion of electrical energy using localized elements. Present the complex quantities associated with sinusoidal quantities, determine the different variables and powers in an electrical system in established sinusoidal regime. Study three-phase systems in sinusoidal regime using symmetrical components. - Magnetic circuits (3h lecture, 2h tutorial): Modeling magnetic circuits using permeance networks. Modeling and sizing magnetically coupled inductances. - Single-phase transformers (3h lecture, 2h tutorial, 4h lab work): Presentation of the different types of transformers depending on the application. Presentation of the single-phase transformer model and identification of its parameters. Determination of the performance of single-phase transformers integrated in a single-phase network. - Three-phase transformers (3h lecture, 4h tutorial, 4h lab work): Presentation of the single-phase equivalent model of three-phase transformers and methods for identifying its parameters. Determination of the performance of three-phase transformers integrated into three-phase networks. Conditions for paralleling transformers. Presentation of autotransformers

| EC 5JEPPN1 | Signals and systems - modeling | UE 5JUPPN01 Fundamental sciences | V. Louis-Dorr |
|---|---|---|---|

**Total hours : 36**
**Lecture hours : 19**
**Tutorials hours : 7**
**Practical/lab hours : 10**

## Objective

The objective is to train students in modeling continuous-time and/or discrete-time systems. Regarding the continuous part, the training provides know-how on the time and frequency analysis of signals and on the analysis of linear and translation-invariant systems. This course allows the introduction of basic signal processing tools. The typical application is the functional analysis of the instrumentation chain. The second part concerns the modeling of event-based systems.

## Skills acquired

Be able to manipulate classical mathematical models of signals and systems (transfer function, differential equation, impulse response, convolution, etc.), know how to solve a simple analog signal processing problem Ability to model and analyze discrete event systems using language theory and finite state automata.

## Prerequisites

First and second order physical systems and linear differential equations

## Assessment

Continuous assessment and end-of-semester assessment and assessment of the acquisition of practical skills over 10 hours of practical work

## Teaching program

CM1 to CM2 Classification of continuous-time, discrete-time, deterministic or random signals, definition of the energy and power of a signal (instantaneous, average), concept of correlation. CM3 to CM6 Linear and translation-invariant dynamic system: definition, impulse response, convolution, transfer function, frequency analysis. Identification of first- and second-order linear systems CM7 to CM9 Analog filtering: concept of noise in signals, noise generated in electronic components, signal-to-noise ratio, modeling of narrowband noise. First- and second-order impulse and step response. Analysis and synthesis of analog passive and active filters, template, first and second order, harmonic response, Bode diagram, polynomial approximations of Butterworth, Tchebychev, Bessel. CM10 to CM12 Application of analog amplitude modulation-demodulation: Interest of modulation in information processing. CM13 to CM17 Boolean algebra of Boolean variables and Boolean functions, Introduction to discrete event systems modeling: concepts of events and states, discretization of states and time, Language theory and Finite State Automata: words and languages, operations on languages, prefix closure, regular expressions, Kleene's theorem, operations on automata (product and synchronous composition, determinization). Introduction to supervision theory (Supervisory Control Theory of Ramadge & Wonham): generator, supervisor, L(S/G) language, controllability, defended states, weakly defended states, controllable supreme, synthesis algorithm (Kumar).

| | | | |
|---|---|---|---|
| ***EC 5JEPPN2*** | **Programming and algorithms** | ***UE 5JUPPN02 Engineering Sciences 1*** | ***?*** |

**Total hours : 36**
**Lecture hours : 11**
**Tutorials hours : 10**
**Practical/lab hours : 15**

Objective

The objective of this EC is to acquire and consolidate the basics of Python programming, algorithms and architectures of processors and microcontrollers: numbering system and assembler, Python programming, basic algorithms (sorting, searching)

Skills acquired

- Design and understand basic algorithms - Develop programs in Python language - Understand how a processor/microcontroller works

Prerequisites

None

Assessment

- Know how to design an algorithm for a given problem - Know how to develop a program in Python language Assessment methods: continuous assessment and a practical final exam on a computer

Teaching program

This EC is broken down into 5 tutorials and 5 practical exercises: The 5 tutorials: tutorial 1: Numbering systems (integer, relative, real) tutorial 2: Representation of floating point numbers and introduction to assembler tutorial 3: Programming in machine language (assembler) TD4: Algorithms in 2-dimensional arrays (Othello game) tutorial 5: The Power 4 game The 5 Practical Exercises: - TP1: Programming a processor in assembler - TP2: Structured Python programming - TP3: Programming the Othello game - TP4: The Power 4 game - TP5: Synthesis

| EC 5JEPPN2 | Foundations of mathematics for engineers | UE 5JUPPN02 Engineering Sciences 1 | V. Lecuyer |
|---|---|---|---|

**Total hours : 49**
**Lecture hours : 20**
**Tutorials hours : 29**
**Practical/lab hours : 0**

Objective

Master the mathematical concepts useful for engineering sciences.

Skills acquired

During this course, apprentices will: - improve their reasoning skills, - master the mathematical concepts useful for engineering sciences. 2 hours of lecture and 10 hours of tutorial are reserved at the very beginning of the semester for revision in mathematics.

Prerequisites

Final year mathematics program. And in addition: matrix calculus, integral calculus, differential calculus, functions of one variable, functions of several variables.

Assessment

A test in November, continuous assessment

Teaching program

The program covers knowledge reviews and an introduction to basic mathematics for the engineer as a tool. Continuity; Differential calculus; Integral calculus (of lines, surface and volume); Modeling for Engineering Sciences; Linear algebra; Differential equations. The course will be illustrated with exercises (physical examples taken from the industrial world), so that apprentices approach the concepts using inductive methods.

| EC 5JEPPN2 | Transformation & complex analysis | UE 5JUPPN02 Engineering Sciences 1 | V. Lecuyer |
|---|---|---|---|

**Total hours : 31**
**Lecture hours : 16**
**Tutorials hours : 15**
**Practical/lab hours : 0**

Objective

Master the mathematical concepts useful for engineering sciences.

Skills acquired

Transformations: During this course, students will: - improve their reasoning skills, - master the mathematical concepts useful for engineering sciences. Complex analysis: Mastery of complex variable functions and the links between harmonicity and holomorphy.

Prerequisites

Foundations of mathematics for S5 engineers

Assessment

Continuous assessment

Teaching program

Transformations: Convolution; The Laplace transform; Hilbert spaces; Fourier series; The Fourier transform of functions. Complex analysis: Complex differentiability; Holomorphism; Link with conformal transformations; Curvilinear integrals; Cauchy's theorem and integral formula; Link between harmonicity and holomorphism; Analytic functions; Complex trigonometry; Logarithmic function; Analytic functions; Singularities of holomorphic functions. The course will be illustrated with exercises (physical examples taken from the industrial world), so that apprentices approach the concepts using inductive methods.

| EC 5JEPPN2 | Energy efficiency and sustainable development | UE 5JUPPN02 Engineering Sciences 1 | T. Boileau |
|---|---|---|---|

**Total hours : 6**
**Lecture hours : 6**
**Tutorials hours : 0**
**Practical/lab hours : 0**

Objective

Understanding the economic and social challenges of energy transition and sustainable development

Skills acquired

Ability to take into account the economic and social challenges of energy transition and sustainable development

Prerequisites

None

Assessment

In-person attendance at conferences

Teaching program

This EC, mainly delivered in the form of industrial conferences, aims to provide all ENSEM students with a solid scientific culture in the field of energy and sustainable development. It is devoted to the issues and challenges of energy efficiency and sustainable development: performance of energy systems in terms of energy efficiency, optimization of energy use in the field of transport or industrial processes, accommodation of energy supply to demand, methods and tools for sustainable development. Energy efficiency: - energy yields - passive and active energy efficiency measures - co-generation - circular economy Sustainable development: - the 3 pillars of sustainable development: the environment, the social and the economy. - product life cycles, systems: modeling and analysis tools - development indicators - analysis and evaluation tools and methods

| EC 5JEPPN3 | English 1 | UE 5JUPPN03 Humanities 1 | S. Gallaire |
|---|---|---|---|

**Total hours : 24**
**Lecture hours : 0**
**Tutorials hours : 24**
**Practical/lab hours : 0**

## Objective

The aim of this course is to consolidate students' knowledge in the 4 language activities (written production, oral production, continuous and interactive, written comprehension, oral comprehension), to bring weaker students up to speed, to meet (at least) the English quitus level B1 (see CECRL or CTI 2010 description) aiming for B2. To develop professional skills.

## Skills acquired

Professional skills and know-how: written and oral comprehension, written and oral production (continuous and interactive) in a foreign language.

## Prerequisites

Have followed instruction in this language, as LV1 or second foreign language, during secondary studies, i.e. for at least 5 years. Have at least level B1

## Assessment

Students are assessed through continuous assessment in listening and reading on activities related to the TOEIC, in writing on professional writings and in speaking.

## Teaching program

Students are offered activities aimed at perfecting the 4 language activities while keeping in mind the final professional tasks. Introduction to the TOEIC test. Consolidation of grammatical and lexical bases. Work on improving oral and written skills in order to be able to write professional documents such as a CV, a cover letter and a technical report in English. Knowing how to highlight academic and professional skills orally. Action-oriented approach: the activities and materials used in class link skills to communicative tasks

| EC 5JEPPN3 | second foreign language-1 English support | UE 5JUPPN03 Humanities 1 | S. Gallaire |
|---|---|---|---|

**Total hours : 24**
**Lecture hours : 0**
**Tutorials hours : 24**
**Practical/lab hours : 0**

## Objective

The aim of this course is to consolidate students' knowledge in the four language activities (written production, interactive oral production, written comprehension, oral comprehension), and to bring weaker students up to speed in English, so that they meet (at least) level B1 of the CEFR, aiming for B2. It also aims to develop professional skills.

## Skills acquired

Professional skills and know-how: written and oral comprehension, written and oral production (continuous and interactive) in a foreign language. Knowing how to set goals, learning how to learn.

## Prerequisites

For students who have not yet reached a B2 level in English, the second language will take the form of an English skills reinforcement course. Students who have already validated the B2 level in English will be able to follow courses in one of the second languages taught at ENSEM (groups will be opened according to the number of students concerned).

## Assessment

Students are assessed through continuous assessment in the 4 language skills.

## Teaching program

Apprentices are offered activities aimed at perfecting the four language activities. Emphasis is also placed on consolidating grammatical and lexical foundations. Materials and methods are adapted according to the level. Action-oriented approach: the activities and materials used in class link skills to communicative tasks. German and Spanish: refresher. General and everyday language work: knowing how to talk about yourself, your situation, and your daily activities (studying, living, playing sports, etc.).

| EC 5JEPPN3 | Project management | UE 5JUPPN03 Humanities 1 | J.-C. Marpeau |
|---|---|---|---|

**Total hours : 10**
**Lecture hours : 0**
**Tutorials hours : 0**
**Practical/lab hours : 10**

Objective

Acquire the basics of engineering project management and know how to present yourself in relation to your professional project.

Skills acquired

Analysis of needs and identification of project issues Understanding the drafting of specifications Writing a specification document Planning and identifying project monitoring criteria Leading project meetings, writing reports, writing activity reports

Prerequisites

Scientific and technical skills at CPGE level, common sense and open-mindedness, Mastery of the French language

Assessment

Assessment in the form of a multiple-choice questionnaire

Teaching program

tutorial 1: - What is a project? - Systemic vision and complexity of a project tutorial 2: - Contextualization of a project and analysis of needs - From needs to functions tutorial 3: - Risks and opportunities - Converging towards a solution tutorial 4: - Planning your project - monitoring your project tutorial 5 - closing your project - Documentation, supports and tools

| EC 5JEPPN3 | Communication 1 | UE 5JUPPN03 Humanities 1 | A. Thimon |
|---|---|---|---|

**Total hours : 16**
**Lecture hours : 0**
**Tutorials hours : 16**
**Practical/lab hours : 0**

Objective

Self-knowledge. Knowing how to present and list your skills, know-how and interpersonal skills. - CV, cover letter and email. - Knowing how to think about your career plan. - Interpersonal skills in business. - PowerPoint presentation

Skills acquired

Knowing how to present yourself. - Knowing how to identify your skills and think about your career plan. - Business skills. - Writing a CV, using social media - Creating a PowerPoint presentation.

Prerequisites

Good command of the French language

Assessment

oral assessments representing 60% (each assessment representing 30%) of the grade and a written assessment representing 40% of the final grade

Teaching program

Using grids and questionnaires, learn to identify your skills, interpersonal skills, know-how, and knowledge in order to create a CV, a portfolio, and use professional networks. - Writing cover letters and emails (spontaneous applications and in response to an advertisement). - Interpersonal skills in business. - Writing a PowerPoint presentation. - Each session includes a grammar/vocabulary refresher.

| EC 5JEPPN3 | Workplace Safety 1 | UE 5JUPPN03 Humanities 1 | T. Boileau |
|---|---|---|---|

**Total hours : 8**
**Lecture hours : 8**
**Tutorials hours : 0**
**Practical/lab hours : 0**

Objective

The objective of this module is to provide students with the necessary knowledge to validate the theoretical and practical part of the electrical qualification at the "BE Essai" level.

Skills acquired

Behavior should be appropriate in the presence of electrical voltage. Know how to take the necessary measures to avoid putting yourself in danger in the presence of electrical voltage. React appropriately in the event of an electrical accident.

Prerequisites

Basic laws of electricity (Ohm's law, mesh law, node law, Ampere's theorem and Laplace's force)

Assessment

Evaluation in S6

Teaching program

Lectures Physiological effects of current Electrical equipment (standardized diagrams, functions) Safety measures (against direct and indirect contact) Protective equipment Safety instructions (area and distance to be respected) Lockout Authorization levels Life-saving actions Intervention in the event of a fire

| EC 5JEPPN3 | French language clearance 1 | UE 5JUPPN03 Humanities 1 | A. Quesada |
|---|---|---|---|

**Total hours : 1**
**Lecture hours : 0**
**Tutorials hours : 1**
**Practical/lab hours : 0**

## Objective

For students whose mother tongue is not French: 100% validation of level 2 at the end of semester 6. For students whose mother tongue is French: 100% validation of level 3 at the end of semester 6

## Skills acquired

Improvement of the French language with the achievement of a specific level (2 or 3 depending on the mother tongue). Possibility of going beyond the imposed objective, up to 100% of level 4. Reduction, or even disappearance of errors made by the student in grammar and spelling. Training in the ability to work independently and regularly, at the rate of one hour per week.

## Prerequisites

Have an A2 level in French if French is not your mother tongue

## Assessment

French language quitus indexed to obtaining 100% of level 2 or 3, depending on the mother tongue. Semester quitus which conditions the obtaining of the Human Sciences UE.

## Teaching program

Independent work on French grammar and spelling on the Orthodidacte e-learning platform. A diagnostic assessment is carried out by each student at the beginning of the year on the platform. Based on this assessment, a personalized course is established. Rules are reviewed and errors are gradually eliminated, following the progression established by the platform. Continuous progress is made until the set objective is reached, or even beyond.

| *EC* | **Technical competence** | *UE 5JUPPN04 S5 Company* | |
|---|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Identify the technical areas of the company: specification, design, development, testing, maintenance of energy systems (production, transport, distribution, storage, efficiency)... Know how to implement them with assistance

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

| EC | Methodological competence | UE 5JUPPN04 S5 Company | |
|---|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Follow an action plan with your tutor Research and structure information Write a report Analyze and establish a balance sheet of acquisitions

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

| *EC* | **Interpersonal skills** | *UE 5JUPPN04 S5 Company* | |
|---|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Integrate into the company Dialogue and report Be an active participant in work meetings Identify interlocutors and their functions

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

## Objective

Missing information

## Skills acquired

Missing information

## Prerequisites

Missing information

## Assessment

Missing information

## Teaching program

Missing information

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**Academic year 2025-2026**
**Detailed curriculum 2025-2026 NRJ_FISA**

## Semester S6

| Code | Course Unit | ECTS | Code | Course | Coeff | *Teacher* | Vol | CM | TD | TP |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ? | The basics of continuum mechanics | 0.2 | *C. Laurent* | **36** | 22 | 14 | 0 |
| | | | 6JEPPN11 | Fluid mechanics | 0,2 | *M.Bordron* | **36** | 14 | 10 | 12 |
| | | | 6JEPPN12 | Electrical machines | 0,2 | *D. Netter* | **36** | 17 | 10 | 9 |
| | | | 6JEPPN13 | Power electronics | 0,2 | *S. Rael* | **36** | 17 | 10 | 9 |
| 6JUPPN01 | Applied Sciences and Technology | **10** | 6JEPPN14 | Systems control | 0,2 | *P. Riedinger* | **36** | 13 | 14 | 9 |
| | | | 6JEPPN20 | Object-oriented programming and algorithms | 0,4 | *T. Docquier* | **36** | 11 | 10 | 15 |
| | | | 6JEPPN22 | Probability and statistics | 0,2 | *A. Gueudin* | **22** | 10 | 12 | 0 |
| 6JUPPN02 | Engineering Sciences 2 | **5** | 6JEPPN21 | Numerical analysis | 0,4 | *V. Lecuyer* | **31** | 16 | 15 | 0 |
| | | | 6JEPPN30 | English 2 | 0,3 | *S. Gallaire* | **32** | 0 | 32 | 0 |
| | | | 6JEPPN31 | second foreign language-2 English support | 0,3 | *S. Gallaire* | **24** | 0 | 24 | 0 |
| | | | 6JEPPN35 | Business environment | 0,2 | *F. Temsamani* | **10** | 10 | 0 | 0 |
| | | | 6JEPPN31 | Communication 2 | 0,2 | *A. Thimon* | **12** | 0 | 12 | 0 |
| | | | 6JEPPN33 | Workplace Safety 2 | pass/fail | *T. Boileau* | **3,5** | 3 | 0 | 0,5 |
| 6JUPPN03 | Humanities 2 | **5** | 6JEPPN34 | French language clearance 2 | pass/fail | *A. Quesada* | **1** | 0 | 1 | 0 |
| | | | | Technical competence<br>Methodological competence<br>Interpersonal skills | | | | | | |
| 6JUPPN04 | S6 Company | **10** | 6JEPPN40 | Defense 1A | | | **0,5** | 0 | 0,5 | 0 |

| EC ? | The basics of continuum mechanics | UE 6JUPPN01 Applied Sciences and Technology | C. Laurent |
|---|---|---|---|

**Total hours : 36**
**Lecture hours : 22**
**Tutorials hours : 14**
**Practical/lab hours : 0**

Objective

The objective of this course is to provide students with the basic concepts enabling them to approach and solve various problems related to the mechanics of deformable solids and fluid mechanics. After a review of the various prerequisites of mechanics (kinematics and dynamics of the point and the non-deformable solid), the kinematics of a continuous medium is described, then the internal forces within this medium, as well as an introduction to the behavior of solid and fluid materials. The applications in tutorial are mainly articulated around energy storage issues.

Skills acquired

Students will be able to describe internal movements and forces in a continuous medium, will be able to solve basic problems in deformable solid mechanics as well as in fluid mechanics, and will be prepared for in-depth courses in these two areas.

Prerequisites

Basic knowledge of differential calculus and matrix calculus

Assessment

The assessment will take place on the basis of four tests spread throughout the module, covering the resolution of basic exercises in solid mechanics and fluid mechanics.

Teaching program

Lectures: Review of point mechanics and solid mechanics Introduction to tensor calculus Continuous media: definition, applications Kinematics of continuous media: representation of movement, deformation of continuous media Dynamics of continuous media: representation of internal forces, properties of the stress tensor Application to solid media: the isotropic linear elastic solid Application to fluid media: the Newtonian fluid Tutorials: tutorial 1: Review of mechanics of the non-deformable solid: stability of the heavy dam tutorial 2: Calculation of fields: study of classical flows tutorial 3: Deformation of the continuous medium: crushing of a solid tire tutorial 4: Study of stresses: pressure tank tutorial 5: Study of the tensile test tutorial 6: Application to dimensioning: transmission shaft tutorial 7: Flow of a fluid: friction around a flywheel

| EC 6JEPPN1 | Fluid mechanics | UE 6JUPPN01 Applied Sciences and Technology | M.Bordron |
|---|---|---|---|

**Total hours : 36**
**Lecture hours : 14**
**Tutorials hours : 10**
**Practical/lab hours : 12**

## Objective

The objective of this module is to teach students the basics of fluid mechanics: Calculating forces on an obstacle and calculating a hydraulic network. The last part focuses on the relevant formulation of a mechanical or thermal problem (Dimensional Analysis).

## Skills acquired

Knowledge: calculating flow forces on an obstacle calculating a hydraulic network Operating point of a pump

## Prerequisites

Course in Mechanics of Continuous Media, Stress Tensors, Newtonian Closure, Navier-Stokes Equations, Tensors, Divergence Operators, Rotational

## Assessment

The final assessment, lasting 120 minutes, covers both parts of the course (calculating force and pressure losses). One exercise per part. Authorized documents: None (tables will be provided where applicable). Non-communicating calculator required.

## Teaching program

Hydrostatics: Fundamental Equation, principle of fluid manometer, force on a dam, force on an immersed body, densimeter - Perfect fluid: Bernoulli, definition of the head of a fluid, Pitot tube, Venturi, diaphragm - Example of calculation of forces on an obstacle by application of the global quantity of movement. - Viscous fluid and pressure losses: calculation of simple flow between two planes or in a cylindrical pipe. Poiseuille's law. Principle of a viscometer. Turbulent flows Blasius' law. Singular pressure loss - Operating point of a pump - Dimensional Analysis and Similarity Practical work: calculation of pressure/force losses and introduction to Fluent software

| EC 6JEPPN1 | Electrical machines | UE 6JUPPN01 Applied Sciences and Technology | D. Netter |
|---|---|---|---|

**Total hours : 36**
**Lecture hours : 17**
**Tutorials hours : 10**
**Practical/lab hours : 9**

## Objective

Understand the operating principles of electrical machines based on electromagnetic phenomena

## Skills acquired

Understand the operating principles of electrical machines based on electromagnetic phenomena. Know the equivalent electrical diagrams of electrical machines in steady state for a linear operating mode. Know how to connect an electrical machine to its power supply and use the appropriate measuring instruments. Implement the experimental protocol for measuring the electrical parameters of electrical diagrams.

## Prerequisites

Basic electrical circuits

## Assessment

Continuous assessment.

## Teaching program

Electromagnetism for electrical machines. Operating principle, modeling, and characterization of the direct current machine. Operating principle, modeling, and characterization of the synchronous machine. Operating principle, modeling, and characterization of the asynchronous machine.

| EC 6JEPPN1 | Power electronics | UE 6JUPPN01 Applied Sciences and Technology | S. Rael |
|---|---|---|---|

**Total hours : 36**
**Lecture hours : 17**
**Tutorials hours : 10**
**Practical/lab hours : 9**

Objective

Understand how a static converter works and how to implement it

Skills acquired

On the theoretical level: operation of a static converter, sizing concepts. On the practical level: Implementation of static converters for the power and control sections. Methods and equipment for measuring complex electrical signals.

Prerequisites

S5 Electrical Circuits Module

Assessment

Report on tutorials and practical work and continuous assessment

Teaching program

Study of static converters, devices ensuring the control of electrical energy exchanges using semiconductor components. Concept of power switches, switching principle and different conversion modes.

| | | | |
|---|---|---|---|
| ***EC 6JEPPN1*** | **Systems control** | ***UE 6JUPPN01 Applied Sciences and Technology*** | ***P. Riedinger*** |

**Total hours : 36**
**Lecture hours : 13**
**Tutorials hours : 14**
**Practical/lab hours : 9**

Objective

At the crossroads of engineering, applied mathematics and physics, Automation is a science that deals with the modeling, analysis and control of dynamic systems. This EC will equip future engineers with the basic skills for modeling, analysis and control of linear dynamic systems. The objective is to master the concept of closed loop and know how to use the basic tools for stability analysis and the calculation of correctors with frequency approaches and state space approaches.

Skills acquired

Modeling of a dynamic system, Analysis of stability and structural properties, synthesis of a regulator

Prerequisites

Mathematics at the 1st cycle level in science or preparatory classes for the grandes écoles in science. Differential calculus. Static Optimization courses.

Assessment

Written exam and practical work report

Teaching program

Lectures - State representation of dynamic systems - Controllability and observability properties. Criteria in the case of linear systems invariant by time translation - State feedback with observer. Eigenvalue separation theorem - Application to the single-input-single-output case - Graphical methods for assessing stability and robustness: Nyquist criterion, stability margins - Rejection of disturbances - Role of classical regulators - Frequency approach for adjusting regulators Practical work: Modeling and control of a Segway robot

| EC 6JEPPN2 | Object-oriented programming and algorithms | UE 6JUPPN02 Engineering Sciences 2 | T. Docquier |
|---|---|---|---|

**Total hours : 36**
**Lecture hours : 11**
**Tutorials hours : 10**
**Practical/lab hours : 15**

Objective

The objectives of this EC are to present the fundamental concepts of algorithm design, object-oriented modeling, and their implementation. This EC is essential for addressing more advanced concepts of embedded, distributed, and network systems in various application areas related to engineering training. It is also a fundamental foundation for any engineering training.

Skills acquired

Design algorithms Model and design in the form of objects Master a programming technique Be autonomous in programming and be able to appropriate other languages

Prerequisites

Information representation, Algorithms and programming, Software tools

Assessment

Continuous assessment and practical experience on a computer machine

Teaching program

Concept of classes, inheritance. Scope of variables and modules. Data structure and associated algorithms (list, sets, dictionary strings). File, Exception. Recursion.

| EC 6JEPPN2 | Probability and statistics | UE 6JUPPN02 Engineering Sciences 2 | A. Gueudin |
|---|---|---|---|

**Total hours : 22**
**Lecture hours : 10**
**Tutorials hours : 12**
**Practical/lab hours : 0**

Objective

The objective of this course is to learn how to manipulate random variables in order to model random problems (which can then be used in signal analysis, system safety, component lifetime modeling, etc.). This course also serves as an introduction to statistics.

Skills acquired

Modeling random phenomena. Calculating probabilities and expectations. Understanding the concept of independent variables. Using the law of large numbers, the central limit theorem, and the normal distribution to calculate probabilities and construct a confidence interval.

Prerequisites

None

Assessment

Assessment by continuous assessment (MCQ) with possibly a final test

Teaching program

Definitions of probability on finite, countable or continuous universes. - Notions of conditional probability, independence, and Bayes' theorem. - Real random variables and vectors and their law (discrete or density). - Distribution function and characteristic function. - Expectation, variance, covariance. - Law of large numbers, central limit theorem and application to confidence intervals. - Beginning of descriptive statistics

| EC 6JEPPN2 | Numerical analysis | UE 6JUPPN02 Engineering Sciences 2 | V. Lecuyer |
|---|---|---|---|

**Total hours : 31**
**Lecture hours : 16**
**Tutorials hours : 15**
**Practical/lab hours : 0**

Objective

Know how to implement computer algorithms (in Matlab) for the simulation of deterministic problems.

Skills acquired

Numerical analysis: apprentices must be able to: - analyze the problem posed, - provide the most suitable numerical method for solving the problem (from implementation to analysis of results), - implement computer algorithms (under Matlab) for the simulation of deterministic problems. Distributions: This prepares for the analysis of partial differential equations and finite element methods.

Prerequisites

Numerical analysis: - S5 mathematics course - Algorithms and basic programming acquired in S5

Assessment

Continuous assessment

Teaching program

Numerical Analysis: Errors in Numerical Analysis; Polynomial Interpolation and Approximation; Numerical Derivation and Integration; Numerical Resolution of Differential Equations. Distributions: Definition and Use of Distributions. The course will be illustrated with exercises (physical examples taken from the industrial world), so that apprentices approach the concepts using inductive methods.

| EC 6JEPPN3 | English 2 | UE 6JUPPN03 Humanities 2 | S. Gallaire |
|---|---|---|---|

**Total hours : 32**
**Lecture hours : 0**
**Tutorials hours : 32**
**Practical/lab hours : 0**

Objective

This module aims to prepare students to work effectively within international teams by enabling them to develop intercultural communication skills.

Skills acquired

Professional skills and know-how: written and oral comprehension, written and oral production (continuous and interactive) in a foreign language in an international context, intercultural skills.

Prerequisites

Have followed instruction in this language, as LV1 or second foreign language, during secondary studies, i.e. for at least 5 years. Have at least level B1

Assessment

The assessment is carried out through continuous monitoring: tests on the content of the workshops, assessment of reports and oral presentation, assessment of the final reflection work.

Teaching program

Students are taking a joint course with the University of Cincinnati: the Global Technical Workforce. They attend various workshops taught jointly (reflection on culture, cross-cultural communication, working efficiently in virtual teams, etc.). They work in Franco-American teams on two projects (one of which is technical), leading them to jointly submit a report and give a comprehensible and interesting oral presentation to a French and American jury. At the end of the course, apprentice students must complete a reflection project on the lessons they learned from this work with American students.

| EC 6JEPPN3 | second foreign language-2 English support | UE 6JUPPN03 Humanities 2 | S. Gallaire |
|---|---|---|---|

**Total hours : 24**
**Lecture hours : 0**
**Tutorials hours : 24**
**Practical/lab hours : 0**

Objective

The aim of this course is to consolidate students' knowledge in the four language activities (written production, interactive oral production, written comprehension, oral comprehension), and to bring weaker students up to speed in English, so that they meet (at least) level B1 of the CEFR, aiming for B2. It also aims to develop professional skills.

Skills acquired

Professional skills and know-how: written and oral comprehension, written and oral production (continuous and interactive) in a foreign language. Knowing how to set goals, learning how to learn.

Prerequisites

For students who have not yet reached a B2 level in English, the second language will take the form of an English skills reinforcement course. Students who have already validated the B2 level in English will be able to follow courses in one of the second languages taught at ENSEM (groups will be opened according to the number of students concerned).

Assessment

Students are assessed through continuous assessment in the 4 language skills.

Teaching program

- Oral comprehension and more or less free or guided oral production work, debates, role plays - General and idiomatic lexical enrichment activities - Consolidation of grammar through manipulation and fixation activities

| EC 6JEPPN3 | Business environment | UE 6JUPPN03 Humanities 2 | F. Temsamani |
|---|---|---|---|

**Total hours : 10**
**Lecture hours : 10**
**Tutorials hours : 0**
**Practical/lab hours : 0**

Objective

•Introduce the fundamental concepts of macroeconomic models to microeconomic foundations. •Understand the interaction of economic actors •Assimilate the exercise of business

Skills acquired

•Have a structured vision of the economy •Interpret the basic concepts of macroeconomic, microeconomic and financial analysis

Prerequisites

None

Assessment

Continuous assessment

Teaching program

•lecture 1: The structures of economic activity •lecture 2: Introduction to macroeconomics •lecture 3: The economic environment •lecture 4: The functions of the company •lecture 5: Marketing and customer relations •lecture 6: Innovation management •lecture 7: The challenges of globalization

| EC 6JEPPN3 | Communication 2 | UE 6JUPPN03 Humanities 2 | A. Thimon |
|---|---|---|---|

**Total hours : 12**
**Lecture hours : 0**
**Tutorials hours : 12**
**Practical/lab hours : 0**

Objective

- Meeting management. - Written expression techniques (argumentation, summary, document synthesis). - Writing the internship report and oral defense.

Skills acquired

- Know how to organize a meeting and write the minutes. - Conflict management and agile methods. - Write an internship report and oral defense. - Written expression techniques: developing an argument, summarizing a text, summarizing documents.

Prerequisites

S6 knowledge and good command of the French language

Assessment

- Oral assessment 50% of the final grade. - Written assessment 50% of the final grade.

Teaching program

- Conflict management. - Agile methods. - Meeting management: the different types of meeting management and practical exercises. Knowing how to write meeting minutes. - Written expression techniques: argumentation, text summary, and the methodology for document synthesis. - The internship report: preparation for writing the internship report and for the oral presentation.

| EC 6JEPPN3 | Workplace Safety 2 | UE 6JUPPN03 Humanities 2 | T. Boileau |
|---|---|---|---|

**Total hours : 3,5**
**Lecture hours : 3**
**Tutorials hours : 0**
**Practical/lab hours : 0,5**

Objective

The first objective of this module is to validate the practical part of the "BE Essai" level accreditation. The second objective is to raise students' awareness of regulations in the areas of health and safety at work.

Skills acquired

At the end of this course, students will know the principles that govern regulations in the fields of health and safety at work, which will allow them to implement them more easily. React appropriately in the event of an electrical accident. Know how to implement the theoretical skills acquired during the theoretical part of the electrical authorization module.

Prerequisites

Theoretical course for S5 accreditation

Assessment

Individual assessment, by verifying the correct implementation of the appropriate safety instructions when carrying out the proposed practical work

Teaching program

Practical work Practical assessment for the "BE Essai" qualification, carrying out an electrical manipulation given by specifications 3 hours of lectures Organization of safety and working conditions Approach to preventing occupational risks Implementation of prevention

| | | | |
|---|---|---|---|
| ***EC 6JEPPN3*** | **French language clearance 2** | ***UE 6JUPPN03 Humanities 2*** | ***A. Quesada*** |

**Total hours : 1**
**Lecture hours : 0**
**Tutorials hours : 1**
**Practical/lab hours : 0**

Objective

For students whose mother tongue is not French: 100% validation of level 2 at the end of semester 6. For students whose mother tongue is French: 100% validation of level 3 at the end of semester 6.

Skills acquired

Improvement of the French language with the achievement of a specific level (2 or 3 depending on the mother tongue). Possibility of going beyond the imposed objective, up to 100% of level 4. Reduction, or even disappearance of mistakes made by the student in grammar and spelling. Training in the ability to work independently and regularly, at the rate of one hour per week

Prerequisites

see an A2 level in French if French is not the mother tongue

Assessment

French language quitus indexed to obtaining 100% of level 2 or 3, depending on the mother tongue. Semester quitus which conditions the obtaining of the Human Sciences UE.

Teaching program

Independent work on French grammar and spelling on the Orthodidacte e-learning platform. A diagnostic assessment is carried out by each student at the beginning of the year on the platform. Based on this assessment, a personalized course is established. The students review the rules and gradually eliminate errors by following the progression established by the platform. Continuous progress is made until the set objective is reached, or even beyond.

| *EC* | **Technical competence** | *UE 6JUPPN04 S6 Company* | |
|---|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Identify the technical areas of the company: specification, design, development, testing, maintenance of energy systems (production, transport, distribution, storage, efficiency)... Know how to implement them with assistance

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

| *EC* | **Methodological competence** | *UE 6JUPPN04 S6 Company* | |
|---|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Develop and follow an action plan with your tutor. Obtain information. Write a report (technical report). Analyze and establish a balance sheet of technical, organizational, human and economic acquisitions.

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

| *EC* | **Interpersonal skills** | *UE 6JUPPN04 S6 Company* | |
|---|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Dialogue and report Being an active participant in work meetings Identifying interlocutors and their functions

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

| EC 6JEPPN4 | Defense 1A | UE 6JUPPN04 S6 Company |
|---|---|---|

**Total hours : 0,5**
**Lecture hours : 0**
**Tutorials hours : 0,5**
**Practical/lab hours : 0**

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

**ECOLE NATIONALE SUPERIEURE**
**D'ELECTRICITE ET DE MECANIQUE**
2, Avenue de la Forêt de Haye
54500 Vandoeuvre-lès-Nancy

**Academic year 2025-2026**
**Detailed curriculum 2025-2026 NRJ_FISA**

## Semester S7

| Code | Course Unit | ECTS | Code | Course | Coeff | *Teacher* | Vol | CM | TD | TP |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 7JEPPN10 | Dynamics of solids and structures | 0,2143 | *J.-F. Schmitt* | **25** | 16 | 9 | 0 |
| | | | 7JEPPN11 | Fluid mechanics | 0,2143 | *A. Pereira* | **25** | 17 | 4 | 4 |
| | | | 7JEPPN12 | Static converters and EMC | 0,2857 | *S. Pierfederici* | **40** | 14 | 10 | 16 |
| 7JUPPN01 | Foundation for energy systems modeling | **7** | 7JEPPN13 | Transmission of information in an industrial context | 0,2857 | *V. Louis-Dorr* | **50** | 20 | 10 | 20 |
| | | | 7JEPPN20 | Regulation design office | 0,125 | *M.Urbain* | **20** | 0 | 0 | 20 |
| | | | 7JEPPN21 | partial differential equations | 0,125 | *B. Remy* | **22** | 10 | 12 | 0 |
| | | | 7JEPPN22 | Introduction to heat transfers | 0,1875 | *S. Didierjean* | **30** | 16 | 8 | 6 |
| | | | 7JEPPN25 | Electric power networks 1 | 0,125 | *S. Dufour* | **20** | 8 | 0 | 12 |
| | | | 7JEPPN23 | Electrical Machines | 0,1875 | *N. Takorabet* | **30** | 10 | 8 | 12 |
| 7JUPPN02 | Modeling of energy systems | **8** | 7JEPPN24 | Modeling, simulation and regulation of digital systems | 0,25 | *J. Daafouz* | **40** | 14 | 8 | 18 |
| | | | 7JEPPN30 | English Preparation Certification B2 | 0,4 | *C. Corringer* | **24** | 0 | 24 | 0 |
| | | | 7JEPPN31 | second foreign language-3 English support | 0,3 | *C. Corringer* | **24** | 0 | 24 | 0 |
| 7JUPPN03 | Humanities 3 | **5** | 7JEPPN32 | Communication 3 | 0,3 | *A. Thimon* | **20** | 0 | 20 | 0 |
| | | | | Technical competence | | | | | | |
| | | | | Methodological competence | | | | | | |
| | | | | Interpersonal skills | | | | | | |
| 7JUPPN06 | S7 Company | **10** | 7JEPPN60 | Report 2A | | | | | | |

| EC 7JEPPN1 | Dynamics of solids and structures | UE 7JUPPN01 Foundation for energy systems modeling | J.-F. Schmitt |
|---|---|---|---|

**Total hours : 25**
**Lecture hours : 16**
**Tutorials hours : 9**
**Practical/lab hours : 0**

Objective

Review the basics of rigid-body mechanics. Introduce analytical mechanics and the Lagrange formalism with the aim of approaching the analytical and numerical study of vibrating mechanical structures.

Skills acquired

At the end of this course, the apprentice must be able to: - model real mechanical systems and write the corresponding dynamic equations, - model real structures in order to study their vibration behavior.

Prerequisites

Concept of point mechanics and solid mechanics.

Assessment

Continuous assessment: tests (3 to 4) are carried out during the different sessions.

Teaching program

Part 1: Reminders and general theorems of point mechanics and solid mechanics - Kinematics of the non-deformable solid - Angular momentum, kinetic energy, inertia tensor. Part 2: Basics of analytical mechanics - Concept of generalized coordinates - Lagrange formalism - Analysis of the equations of motion - Stability of an equilibrium position - Some numerical concepts for solving the equations of motion. Studies of mechanical structures in vibration. Analytical dynamics of discrete systems with n dof - Undamped and damped oscillations - Resolution of the eigenvalue problem - Search for eigenmodes

| EC 7JEPPN1 | Fluid mechanics | UE 7JUPPN01 Foundation for energy systems modeling | A. Pereira |
|---|---|---|---|

**Total hours : 25**
**Lecture hours : 17**
**Tutorials hours : 4**
**Practical/lab hours : 4**

Objective

This EC explores several aspects of fluid mechanics related to the flows encountered in energy systems

Skills acquired

Calculation and analysis of flows in various configurations. Calculation of the forces exerted by these flows.

Prerequisites

Continuous media mechanics and applied fluid mechanics (1A)

Assessment

Examination of the concepts seen in class and the study of a practical flow situation

Teaching program

The following topics will be covered in particular: flow modeling; boundary layer and wake; vorticity. Tutorial and practical sessions devoted to these topics will complement the concepts covered in class.

| | | | |
|---|---|---|---|
| ***EC 7JEPPN1*** | **Static converters and EMC** | ***UE 7JUPPN01 Foundation for energy systems modeling*** | ***S. Pierfederici*** |

**Total hours : 40**
**Lecture hours : 14**
**Tutorials hours : 10**
**Practical/lab hours : 16**

Objective

Knowledge of the main types of DC DC converters and phenomena related to electromagnetic compatibility

Skills acquired

Knowledge of the main types of isolated/non-isolated DC DC converters used in electrical energy conversion devices, their specific constraints and their sizing. Knowledge of phenomena related to electromagnetic compatibility, their modeling and the sizing of common mode and differential mode filters.

Prerequisites

None

Assessment

Written exam + practical work/tutorial report

Teaching program

The apprentice will analyze the operation of the main switching power supplies with or without galvanic isolation. Dynamic models for control will be developed and the main control structures implemented. A large place will be given to simulation and experimentation in this module. For the EMC part, the apprentice will be confronted with the problems of differential mode and common mode filtering in power electronic devices. The teaching will include a numerical simulation part using Matlab/Saber tools and an experimental component.

| EC 7JEPPN1 | Transmission of information in an industrial context | UE 7JUPPN01 Foundation for energy systems modeling | V. Louis-Dorr |
|---|---|---|---|

**Total hours : 50**
**Lecture hours : 20**
**Tutorials hours : 10**
**Practical/lab hours : 20**

Objective

Understand the fundamentals of signal processing, information theory and master the tools and their implementations in digital, baseband, and transposed data transmissions. The modeling of transmission media is covered as well as the format and coding of data, analyze the tools of source coding and the concepts of compression, source adaptation to the channel

Skills acquired

Know how to handle time and frequency analysis tools for digitized time series as well as the associated digital filters Know how to model and analyze a transmission chain using wired or wireless media

Prerequisites

1A signal and system modeling, functional analysis, distribution theory, Fourier series and transform, probabilities

Assessment

Assess the ability to handle theoretical tools and know how to implement numerical models and simulate scenarios, estimate sensitivity to parameters

Teaching program

Digital Signal Processing Sampling Theorem Sampling and Series Digital Signals and Processing: Digital Filtering Frequency Analysis of Digital Filters Modeling of Transmission Media Sampling and Nonlinear Quantization Digital Data Format in the Physical Layer Definition of Valence, Modulation Rate, Bit Rate, Power Spectral Density of Digital Transmissions Physical Layers in Transmission Networks Transmission Signal Analysis: Intersymbol Interference, Eye Diagram, Nyquist Filter, Effect of Filtering on Phase Trajectory, Modulation of Digital Data, Time and Frequency Division Multiplexing for Wireless Networks.

| EC 7JEPPN2 | Regulation design office | UE 7JUPPN02 Modeling of energy systems | M.Urbain |
|---|---|---|---|

**Total hours : 20**
**Lecture hours : 0**
**Tutorials hours : 0**
**Practical/lab hours : 20**

Objective

This study is a multidisciplinary one, it deals with different scientific fields, namely electrotechnic, power electronics, and automatic. The objective of this workshop is to control both current and speed of a 5kW direct current electrical machine. The required theory is systematically provided at each step of the way. Practical application is then proceeded on the test bench for experimental tests and for design validation.

Skills acquired

Modeling of the conversion system {source + power electronics converter + DC motor}.Static and dynamic parameters determination through measurements and experimental tests.Linear control design.Proceed to dynamic upstream validation through simulation on Matlab/Simulink Software.Observe and analyze waveforms and measurements on the oscilloscope.Assess dynamic, accuracy and stability on the test bench.Asses the global efficiency of the conversion chain.Complete of a comprehensive experimental tests and study report.

Prerequisites

Power electronics S6Electrical machines S6System control S6

Assessment

The module assessment is based entirely on the project report.

Teaching program

Practical wokrhsop :Modeling of the conversion system {source + power electronics converter + DC motor}.Static and dynamic parameters determination through measurements and experimental tests.Linear control design.Proceed to dynamic upstream validation through simulation on Matlab/Simulink Software.Observe and analyze waveforms and measurements on the oscilloscope.Implement the control on dSPACE rapid prototyping card.Design the interface layout on Controldesk software.Assess dynamic, accuracy and stability on the test bench.Asses the global efficiency of the conversion chain.Complete of a comprehensive experimental tests and study report

| | | | |
|---|---|---|---|
| ***EC 7JEPPN2*** | **partial differential equations** | ***UE 7JUPPN02 Modeling of energy systems*** | ***B. Remy*** |

**Total hours : 22**
**Lecture hours : 10**
**Tutorials hours : 12**
**Practical/lab hours : 0**

Objective

Probability: Modeling, simulation of random phenomena. partial differential equations: Modeling, simulation of deterministic problems

Skills acquired

Probability: Modeling, simulation of random phenomena. partial differential equations: Modeling, simulation of deterministic problems.

Prerequisites

Probability: S5 mathematics course. partial differential equations: - S5 mathematics course; - S6 distributions course

Assessment

An exam

Teaching program

Probabilities: - Definitions of probability on finite, countable or continuous universes. - Notions of conditional probability. - Real random variables and vectors and their law (discrete or density). - Expectation, variance, covariance. - Law of large numbers, central limit theorem and application to confidence intervals. PDE: Resolution of PDEs, finite element methods. The course will be illustrated with exercises (physical examples taken from the industrial world), so that apprentices approach the concepts by inductive methods

| EC 7JEPPN2 | Introduction to heat transfers | UE 7JUPPN02 Modeling of energy systems | S. Didierjean |
|---|---|---|---|

**Total hours : 30**
**Lecture hours : 16**
**Tutorials hours : 8**
**Practical/lab hours : 6**

Objective

The objective of this course is to provide students with the basic concepts that will enable them to approach and solve various problems related to thermal energy transfer. The three modes of transfer are presented and illustrated with examples.

Skills acquired

Students will be familiar with the terminology and main physical laws of thermal energy transfer. They will be able to describe and model a thermal energy transfer problem, and they will be able to solve it using standard engineering methods.

Prerequisites

Thermodynamics – Energy balance S5 Basics of differential calculus Basics of solving partial differential equations

Assessment

Continuous assessment practical work report

Teaching program

Lectures (16h) Description of the three modes of thermal energy transfer: Conduction, radiation, convection Presentation of the main laws and quantities involved Description of the interactions of the thermal system with its environment Main resolution methods Tutorials (8h) Methodology tutorials, i.e. getting to grips with the concepts and tools in thermal energy transfer by conduction and radiation. Study of cooling fins, Concept of thermal resistances, exchanges by radiation between opaque walls, radiation balance, etc. Practical work (6h) The practical work aims to: Introduce students to temperature metrology Experimentally observe thermal energy transfers by conduction, convection and radiation Analyze experimental data, such as temperature profiles or temporal temperature variations.

| | | | |
|---|---|---|---|
| ***EC 7JEPPN2*** | **Electric power networks 1** | ***UE 7JUPPN02 Modeling of energy systems*** | ***S. Dufour*** |

**Total hours : 20**
**Lecture hours : 8**
**Tutorials hours : 0**
**Practical/lab hours : 12**

Objective

Apprentices will have mastery of modeling network components, and will be able to understand the behavior of an electrical network in established sinusoidal mode.

Skills acquired

Apprentices will have mastery of modeling network components, and will be able to understand the behavior of an electrical network in established sinusoidal mode.

Prerequisites

Electricity and magnetism: S5 circuits

Assessment

Written exam and practical work report

Teaching program

Modeling power lines using an inverted approach, the course will follow the observations made in practical work. Presentation of the architecture of an electrical substation Analysis of power distribution in an interconnected network, presentation using an inverted approach, presentation of the problem in practical work, then course on advanced functionalities. A final part will be devoted to the calculations of short-circuit currents.

| EC 7JEPPN2 | Electrical Machines | UE 7JUPPN02 Modeling of energy systems | N. Takorabet |
|---|---|---|---|

**Total hours : 30**
**Lecture hours : 10**
**Tutorials hours : 8**
**Practical/lab hours : 12**

Objective

Operation of electrical machines in motor and generator modes

Skills acquired

External modeling by an equivalent diagram, Implementation and variable speed drive of electrical machines.

Prerequisites

S5 Electrical Circuits Module, S5 Electromagnetism

Assessment

Practical work report and written exam.

Teaching program

In this module, the principle of electromechanical conversion and the classification of machines are studied in general. A study of the three main types of electrical machines (direct current, synchronous and asynchronous) is then addressed in detail according to the following plan: General description, equivalent circuit model, identification of the parameters of the equivalent diagram, implementation and variable speed drives. A synthetic study of some transient regimes is covered at the end of each part. A significant part is given to the practical implementation of conventional electrical machines.

| EC 7JEPPN2 | Modeling, simulation and regulation of digital systems | UE 7JUPPN02 Modeling of energy systems | J. Daafouz |
|---|---|---|---|

**Total hours : 40**
**Lecture hours : 14**
**Tutorials hours : 8**
**Practical/lab hours : 18**

Objective

This course introduces the concepts and methods of calculating digital control laws. Emphasis is placed on taking into account the constraints of implementing a real-time control. The objective is to master the steps of modeling a digital control loop and calculating an associated control law with stability and performance analysis.

Skills acquired

Being able to carry out a digital command directly and by going through the discretization of an analog command.

Prerequisites

Classic linear servocontrols, elementary properties: stability, controllability, observability.

Assessment

Practical work report and written exam.

Teaching program

This module consists of three parts: - Modeling a digital control loop; - Performance of digital servocontrols; - Design of digital correctors. The first part focuses on the principle of digital control, the modeling of analog-to-digital converters (ADC) and digital-to-analog converters (DAC) and the calculation of the transfer function for a digital control loop. The second part focuses on the stability and dynamic performance (time response, shape of the response as a function of the poles in a closed loop, pole locus and frequency response) of the closed loop. The last part presents different ways of designing digital correctors: discretization of an analog corrector, stack response corrector, RST controller

| EC 7JEPPN3 | English Preparation Certification B2 | UE 7JUPPN03 Humanities 3 | C. Corringer |
|---|---|---|---|

**Total hours : 24**
**Lecture hours : 0**
**Tutorials hours : 24**
**Practical/lab hours : 0**

Objective

The objective of this module is to prepare students for the external certification corresponding to their level and needs. The certifications prepared are as follows: -TOEIC minimum score to reach 785 (level B2) -IELTS minimum score to reach 6 (B2) -DET (Duolingo English Test) minimum score to reach 100 (B2)

Skills acquired

Skills as defined by the CEFR at level B2 or C1

Prerequisites

Have consolidated your B1 level. Have completed the 1A TOEIC test initiation.

Assessment

Continuous assessment: diagnostic, formative and summative assessments (vocabulary, oral/written comprehension type TOEIC/IELTS/DET, written productions type IELTS and/or DET and continuous or interactive oral productions) + Final assessment type TOEIC or IELTS in oral and written comprehension

Teaching program

Work on strategies, formats to master and consolidation of grammatical and lexical bases in order to be more effective in the TOEIC/IELTS/DET tests. TOEIC: Using the manual Preparation for the TOEIC test, Bruce Rogers. Typical exercises, methodology, training on complete tests. IELTS: Typical exercises, methodology, training on complete tests. DET: Typical exercises, methodology

| EC 7JEPPN3 | second foreign language-3 English support | UE 7JUPPN03 Humanities 3 | C. Corringer |
|---|---|---|---|

**Total hours : 24**
**Lecture hours : 0**
**Tutorials hours : 24**
**Practical/lab hours : 0**

Objective

This course aims to consolidate students' knowledge in the four language activities (written production, interactive oral production, written comprehension, oral comprehension), and to bring weaker students up to speed in English, so that they meet (at least) level B2 of the CEFR. It also aims to develop professional skills

Skills acquired

Professional skills and know-how: written and oral comprehension, written and oral production (continuous and interactive) in a foreign language. Knowing how to set goals, learning how to learn

Prerequisites

For students who have not yet reached a B2 level in English, the second language will take the form of an English skills reinforcement course. Students who have already validated the B2 level in English will be able to follow courses in one of the second languages taught at ENSEM (groups will be opened according to the number of students concerned).

Assessment

Continuous monitoring (regular tests + ongoing investment).

Teaching program

In German or Spanish, the B1/B2 level is targeted. The activities in the 5 language activities will be structured around 2 themes: professional language and scientific language. Business and work world. Written expression and written comprehension activities such as CVs, cover letters, reports, summaries, syntheses. In English support, work on various TOEIC preparation and training exercises. The emphasis is on oral comprehension, written comprehension, grammatical and vocabulary reinforcement.

| EC 7JEPPN3 | Communication 3 | UE 7JUPPN03 Humanities 3 | A. Thimon |
|---|---|---|---|

**Total hours : 20**
**Lecture hours : 0**
**Tutorials hours : 20**
**Practical/lab hours : 0**

Objective

- public speaking - Presentation technique - Technical internship report - Analyzing and summarizing a file.

Skills acquired

- Be comfortable speaking verbally in a group and/or individually. - Know how to give a presentation. - Write a technical report. - Write a summary based on a file.

Prerequisites

Knowledge acquired during S5 and S6. Good command of the French language

Assessment

An oral mark (50%) and a written mark (50%)

Teaching program

Presentation technique. The word "work" will be the common thread of the proposed themes (workplace stress, working abroad, entrepreneurial spirit, the circular economy, etc. 35 themes identified). In-depth study of meeting management and practical exercises. The internship report and oral defense. Continuation of reflection on the professional project (including updating the CV, portfolio, etc.).

| *EC* | **Technical competence** | *UE 7JUPPN06 S7 Company* |
|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Use the main techniques of an energy engineer Improve your skills and put them into practice independently

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

| *EC* | **Methodological competence** | *UE 7JUPPN06 S7 Company* | |
|---|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Define an action plan to achieve the objectives set by the tutor Manage short tasks and in-depth tasks Propose reasoned solutions Lead a meeting (minutes, action plan) Carry out and conclude a company mission

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

| EC | Interpersonal skills | UE 7JUPPN06 S7 Company | |
|---|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Give instructions, enforce them and verify their application Develop your assertiveness within a team Acquire autonomy Manage deadlines with internal and external suppliers Implement the expected skills Define resources and means

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

| EC 7JEPPN6 | Report 2A | UE 7JUPPN06 S7 Company |
|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

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**Academic year 2025-2026**
**Detailed curriculum 2025-2026 NRJ_FISA**

## Semester S8

| Code | Course Unit | ECTS | Code | Course | Coeff | *Teacher* | Vol | CM | TD | TP |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 8JEPPN10 | Mechanical and thermal storage, fluid energy conversion | 0,3571 | *O. Caballina* | **40** | 20 | 4 | 16 |
| | | | 8JEPPN11 | Electric power networks 2 | 0,2857 | *J.-P. Martin* | **30** | 12 | 10 | 8 |
| 8JUPPN01 | Energy networks | **7** | 8JEPPN12 | Industrial automation - control and supervision | 0,3571 | *S. Maza* | **40** | 16 | 8 | 16 |
| | | | 8JEPPN20 | Numerical analysis for mechanics | 0,2143 | *B. Remy* | **20** | 4 | 4 | 12 |
| | | | 8JEPPN21 | Thermodynamics of machines and systems | 0,2429 | *S. Didierjean* | **20** | 10 | 10 | 0 |
| | | | 8JEPPN22 | Power Electronics 2 and Drive | 0,2857 | *T. Boileau* | **40** | 14 | 14 | 12 |
| 8JUPPN02 | Modeling and control of energy systems | **7** | 8JEPPN23 | Computer application design | 0,2857 | *YQ Song* | **30** | 10 | 8 | 12 |
| | | | 8JEPPN31 | Dynamic presentations | 0,3333 | *C. Corringer* | **24** | 0 | 24 | 0 |
| | | | 8JEPPN32 | second foreign language-4 English support | 0,3333 | *C. Corringer* | **24** | 0 | 24 | 0 |
| 8JUPPN03 | Humanities 4 | **6** | 8JEPPN30 | Financial Management and Accounting | 0,3333 | *J.-C. Marpeau* | **40** | 22 | 18 | 0 |
| | | | | Technical competence | | | | | | |
| | | | | Methodological competence | | | | | | |
| | | | | Interpersonal skills | | | | | | |
| 8JUPPN04 | S8 Company | **10** | 8JEPPN40 | 2A Defense | | | | | | |

| EC 8JEPPN1 | Mechanical and thermal storage, fluid energy conversion | UE 8JUPPN01 Energy networks | O. Caballina |
|---|---|---|---|

**Total hours : 40**
**Lecture hours : 20**
**Tutorials hours : 4**
**Practical/lab hours : 16**

Objective

The objective of this course is to familiarize students with fluid energy conversion processes used in electrical power generation systems and energy storage devices. This course will only cover the mechanical conversion and mechanical and thermal storage aspects.

Skills acquired

- Know the families of turbomachines, their operating characteristics and their efficiency. - Model their operation using simplified approaches. - Know how to choose and size mechanical energy conversion devices taking into account specifications. - Know how to model and size a mechanical or thermal storage device.

Prerequisites

Introduction to heat transfer Applied fluid mechanics Thermodynamics

Assessment

Mastery of modeling and dimensioning tools will be assessed through continuous assessment by evaluation test and during practical work. Group work ability and report writing will also be assessed during practical work sessions.

Teaching program

The course will cover the following points and aims to provide the physical bases for understanding the operation and dimensioning of turbomachines: 1 - Theory of rotating machines 2 - Hydraulic turbomachines 3 - Wind turbines 4 - Gravity mechanical energy storage (STEP), compressed air (CAES) and flywheels 5 - Thermal energy storage by latent and sensible heat; application to concentrated solar power (CSP) AES) This course will be supplemented by tutorials and practical work: - 4 hours of tutorials to study a practical case of characterization of the different turbomachines seen in class. Prediction of operating characteristics in perfect fluid and correction in real fluid. Use of the notions of similarity - 16 hours of practical work for a characterization of turbomachines in real operation (action or reaction turbine, wind turbine) and for a dimensioning of a storage chain

| | | | |
|---|---|---|---|
| ***EC 8JEPPN1*** | **Electric power networks 2** | ***UE 8JUPPN01 Energy networks*** | ***J.-P. Martin*** |

**Total hours : 30**
**Lecture hours : 12**
**Tutorials hours : 10**
**Practical/lab hours : 8**

Objective

The objectives of this module are, on the one hand, the connection of generators to the transmission or distribution network as well as the control and monitoring of these networks. On the other hand, the objectives focus on the modeling, sizing and implementation of DC microgrid architectures associated with energy management algorithms. The analysis of dynamic stability using tools based on impedance spectroscopy and active stabilization will be presented.

Skills acquired

Know how to meet the specifications for connection to the electricity grid using simplified alternator models. Know how to model, size and implement electrical micro-grid architectures and guarantee the dynamic stability of the system.

Prerequisites

Electrical power network 1, electrical circuits

Assessment

Continuous evaluation through the implementation of projects associated with each part

Teaching program

The module is divided into three parts: - Connection of generators to the electricity grid (lecture: 2h / tutorial: 4h) This part will detail the technical requirements for connecting generators to the transmission or distribution network. The connection specifications will be explained. Simplified models of generators in transient conditions will be developed to meet these specifications, particularly with regard to the stability of generators subject to hazards. Numerical simulations of different cases will be implemented. - The electricity transmission network in France (lecture: 2h / tutorial: 2h) The characteristics of the French electricity transmission network will be presented, as well as its operation and monitoring, and the supply-demand balance through frequency-power control and voltage control. - Study and implementation of an electrical micro-grid with stability analysis and active stabilization (lecture: 8h / tutorial: 6h / lab work: 8h) This part will allow the study of different DC micro-grid architectures associated with centralized energy management laws allowing the distribution of power between the different components. These energy management laws make it possible to take into account the different constraints of sources, loads and storage elements in order to limit the aging of the system. The analysis of the dynamic stability of micro-grids will be introduced based on impedance spectroscopy tools. The active stabilization architectures will be detailed

| EC 8JEPPN1 | Industrial automation - control and supervision | UE 8JUPPN01 Energy networks | S. Maza |
|---|---|---|---|

**Total hours : 40**
**Lecture hours : 16**
**Tutorials hours : 8**
**Practical/lab hours : 16**

Objective

Learn how to model, analyze, and control systems whose dynamics are governed by the occurrence of events. This type of dynamics is found in industrial production and transportation systems, for example. This module complements the automation module, which focuses on continuous systems.

Skills acquired

At the end of this course, apprentices will be able to: - model any automated process characterized by a discrete event system (DES) type behavior, - analyze its properties, particularly those relating to safety or liveliness - design, implement and evaluate the control of an automated process driven by a programmable logic controller (PLC)

Prerequisites

None

Assessment

In three ways: 1- Individually through a written exam, to assess the knowledge acquired. 2- Through a practical work report on a case study on the Petri Nets part. 3- Through a real-time evaluation of a practical work on implementing a command on an API.

Teaching program

The apprentice will study the fundamental concepts and methods for modeling, analyzing, and designing automated processes whose dynamics are governed by the occurrence of events (i.e., EDS type). The module will enable apprentices, on the one hand, to design analysis models, allowing them to evaluate certain important properties (such as the absence of blocking) and also certain performance factors (such as those related to operational safety). On the other hand, they will learn to design the control of these processes which will then be implemented in a programmable logic controller (PLC). The module focuses on methods related to the theory of discrete event systems (DES) where the Petri net and Grafcet formalisms will be studied. The design of control architectures for automated systems will also be covered. A large place will be given to the implementation of the methods taught for the modeling, analysis, and design of automated processes that are specific to production or transport systems.

| EC 8JEPPN2 | Numerical analysis for mechanics | UE 8JUPPN02 Modeling and control of energy systems | B. Remy |
|---|---|---|---|

**Total hours : 20**
**Lecture hours : 4**
**Tutorials hours : 4**
**Practical/lab hours : 12**

Objective

Know how to solve a PDE in the field of "mechanics" using a numerical method such as volumes or finite elements

Skills acquired

1- Model a physical problem using PDEs, 2- discretize it using the two methods studied (VF and EF) 3- put it into matrix form for resolution. 4- choose the methods best suited to solving a given problem in terms of stability and precision.

Prerequisites

Basic numerical analysis course 1A, applied mathematics course (Distributions, Variational analysis, PDE, etc.).

Assessment

Practical work (3 reports), end-of-module test. Final grade = (Laboratory work grade) * 1/3 + (Test) * 2/3

Teaching program

The aim of this course is to acquire the fundamental knowledge in numerical calculation (numerical methods and schemes) necessary for solving problems in Mechanics (Thermal, fluid and mechanical). Program: Finite volumes: - Formulation and discretization of conductive and convective flows (linear, Upwind and Quick) - Resolution of the 2D Navier Stokes equation by SIMPLE scheme - Elements of PDE theory Finite elements: - Weak Variational Formulation (Projection, best approximation in H1) - Minimization of an energy minimization functional - Elements P1, P3. Assembly of stiffness and mass matrices Practical work: The practical work (3 sessions of 4 hours) consists of implementing the numerical schemes (finite volumes – 1 session, finite elements – 2 sessions) seen in class and prepared in tutorial by applying them to thermal engineering (1D and 2D), fluid mechanics (Poiseuille and Couette flows) or elastic solid mechanics (2D).

| | | | |
|---|---|---|---|
| ***EC 8JEPPN2*** | **Thermodynamics of machines and systems** | ***UE 8JUPPN02 Modeling and control of energy systems*** | ***S. Didierjean*** |

**Total hours : 20**
**Lecture hours : 10**
**Tutorials hours : 10**
**Practical/lab hours : 0**

Objective

Having acquired fundamental knowledge in thermodynamics, heat transfer, and mechanical energy conversion, the module focuses on their application to energy systems. The examples covered mainly concern thermal machines for the production of electrical energy and the production of cold. The aim is to present the basic tools necessary for evaluating their energy performance.

Skills acquired

To be able to describe and understand the operating principle of the main elements that make up an energy system. To be able to make assumptions that enable an energy analysis to be carried out and to calculate the efficiency of typical systems for the engineer.

Prerequisites

Thermodynamics S5 Introduction to heat transfers S7

Assessment

Continuous assessment

Teaching program

Lectures (10h) Presentation of the tools and methods that will be applied in tutorials. Energy analysis of open systems, properties of pure substances, phase change, phase diagrams, combustion reminders, introduction to humid air. Presentation of the main applications: gas turbine cycles, engines, steam turbine cycles, heat pump and cold production. Tutorials (10h) Applications to concrete systems: Thermal power plant, combined gas-steam cycle, air conditioning, cold production, etc. Influence of operating parameters on energy performance.

| EC 8JEPPN2 | Power Electronics 2 and Drive | UE 8JUPPN02 Modeling and control of energy systems | T. Boileau |
|---|---|---|---|

**Total hours : 40**
**Lecture hours : 14**
**Tutorials hours : 14**
**Practical/lab hours : 12**

Objective

That the students know the properties of inverters and the implementation conditions That the students know the dynamic modeling tools of three-phase systems That the students know the model of synchronous magnet machines with a view to their controls That the students know how to control an Inverter Synchronous Magnet Machine association

Skills acquired

At the end of this module, students will be able to model and implement a single-phase and three-phase inverter for use in various applications. They will be able to model a Permanent Magnet Synchronous Machine (PMSM) for control. They will be able to model the three-phase PMSM Inverter Control assembly. They will be able to implement a three-phase PMSM Inverter Control assembly.

Prerequisites

All electrical engineering courses from S5, S6 and S7

Assessment

Assessment of practical work reports and written exams

Teaching program

Lectures and tutorials Single-phase inverter Three-phase inverter Tools for dynamic modeling of three-phase systems Modeling and control of the Permanent Magnet Synchronous Machine Practical work Implementation of an inverter Modeling and control of an MSAP inverter assembly Implementation of an MSAP inverter assembly Control

| | | | |
|---|---|---|---|
| ***EC 8JEPPN2*** | **Computer application design** | ***UE 8JUPPN02 Modeling and control of energy systems*** | ***YQ Song*** |

**Total hours : 30**
**Lecture hours : 10**
**Tutorials hours : 8**
**Practical/lab hours : 12**

Objective

This course covers the design and operation of relational databases, ubiquitous in businesses for any IT application, as well as querying via connectors with other computer languages (e.g. Python). It also introduces the use of structured documents in XML language for dynamic web applications. Finally, it provides an opening towards noSQL databases for Big Data.

Skills acquired

- Able to design, implement and operate a relational database (SQL) - Mastery of interfacing techniques between a database and a high-level language - Knowledge of XML format - Knowledge of NoSQL and Big Data databases

Prerequisites

Algorithms and programming (1A)

Assessment

Practical tests to assess skills in querying a database in SQL and noSQL, and in structuring XML documents.

Teaching program

Courses: 1. Introduction to Business Information Systems, Data, Databases and Database Management Systems (DBMS). 2. The Entity/Association Model: Entities, attributes and identifiers. Binary associations. Generalized associations. UML description. 3. The relational model: Definition of a relational schema. Transition from an E/A schema to a relational schema. 4. Relational algebra: The operators of relational algebra. Expressing queries with algebra. 5. The SQL language: Simple queries, queries on several tables, nested queries. Aggregation. Update. 6. Interfacing with high-level languages via connectors (eg, Python). 7. XML and Web Applications 8. Big Data and NoSQL Databases (e.g. MongoDB) Tutorials: 1. Conceptual Data Model (CDM), Logical Data Model (LDM) and Relational Algebra. 2. SQL Queries. 3. XML 4. NoSQL. Practicals: 1. Design, Implementation and Querying a MySQL Database. 2. Querying a MySQL Database via the Python Connector. 3. Implementing XML Data: Structuring, Parsing and Presenting Documents. 4. NoSQL Databases (MongoDB) Keywords: Database, Entity/Association Model, Relational Model, SQL, XML, Big Data, NoSQL.

| EC 8JEPPN3 | Dynamic presentations | UE 8JUPPN03 Humanities 4 | C. Corringer |
|---|---|---|---|

**Total hours : 24**
**Lecture hours : 0**
**Tutorials hours : 24**
**Practical/lab hours : 0**

Objective

Semester focused on oral English: the objective is to lead students to deliver a clear and structured project presentation to an audience using effective communication techniques. Students will work regularly in groups and will be required to analyze their presentations.

Skills acquired

Communication techniques. Optimized use of different presentation tools (PPT, PREZI)

Prerequisites

Have reached a B2 level.

Assessment

Continuous assessment: regular formative and/or summative oral assessments (in the form of recordings and in public, individual and group) and final oral assessment.

Teaching program

Preparation for continuous public speaking: -use of documents (written and audio) in order to work on the structure and expressions necessary for guidance (signposting) -optimization of content and use of slides on PowerPoint or Prezi -management of non-verbal communication -work on pronunciation, rhythm, voice placement -work on communication techniques (impact techniques, rapport building) -work on marketing techniques (elevator pitch, sales speech)

| | | | |
|---|---|---|---|
| ***EC 8JEPPN3*** | **second foreign language-4 English support** | ***UE 8JUPPN03 Humanities 4*** | ***C. Corringer*** |

**Total hours : 24**
**Lecture hours : 0**
**Tutorials hours : 24**
**Practical/lab hours : 0**

Objective

The aim of this course is to consolidate students' knowledge in the four language activities (written production, interactive oral production, written comprehension, oral comprehension), and to bring weaker students up to speed in English, so that they meet (at least) level B2 of the CEFR. It also aims to develop professional skills.

Skills acquired

Professional skills and know-how: written and oral comprehension, written and oral production (continuous and interactive) in a foreign language. Knowing how to set goals, learning how to learn

Prerequisites

For students who have not yet reached a B2 level in English, the second language will take the form of an English skills reinforcement course. Students who have already validated the B2 level in English will be able to follow courses in one of the second languages taught at ENSEM (groups will be opened according to the number of students concerned).

Assessment

Continuous monitoring (regular tests + ongoing investment)

Teaching program

In German and Spanish, the semester will be structured around modules with a scientific and cultural focus. Discovery or deepening of specialist vocabulary and the language of engineering. Work on themes and documents related to the field of engineering, the engineering profession, preparation for writing summaries, reports, training for debates, simulated meetings; knowing how to describe the operation of machines, processes, etc. Preparation for laboratory or company visits. Themes: the engineering profession, manufacturing processes, mechanics, electricity, energy, etc. In English support, the activities will aim to strengthen the skills necessary for continuous and public speaking (use of authentic documents in order to work on the structure, the necessary expressions, the use of slides on Powerpoint or Prezi, non-verbal management).

| EC 8JEPPN3 | Financial Management and Accounting | UE 8JUPPN03 Humanities 4 | J.-C. Marpeau |
|---|---|---|---|

**Total hours : 40**
**Lecture hours : 22**
**Tutorials hours : 18**
**Practical/lab hours : 0**

Objective

Put students in a business management situation through a business management simulation (business game) based on a competitive market scenario. Apply concepts learned in management, marketing, finance, production of goods and project management.

Skills acquired

Ability to integrate into a business organization and understand its workings.

Prerequisites

Business knowledge and project management

Assessment

Evaluation based on feedback from the business management simulation tutorial (Strategy, Finance and Project Management). Presentation of results in the form of an oral presentation.

Teaching program

lecture: - Basics of accounting and financial analysis - Business strategy - Financial evaluation of a project and its impact on the company - Law and elements of responsibility of an engineer tutorial: In the form of a business management simulation Based on group work, this business management simulation offers an effective way to concretely understand the interweaving of commercial, financial, human, technical decisions and the company's relations with its environment. It gives everyone the opportunity to test their ability to react to the vagaries of the economic situation, to the blows of competition, from imperfect information and in necessarily limited time.

| EC | Technical competence | UE 8JUPPN04 S8 Company |
|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Use the main techniques of an energy engineer (level 2) Perfect your skills (level 2)

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

| *EC* | **Methodological competence** | *UE 8JUPPN04 S8 Company* | |
|---|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Define an action plan to achieve the objectives set by the tutor (level 2) Manage short tasks and in-depth tasks (level 2) Solve a cross-functional problem in the company Lead a meeting (minutes, action plan) (level 2)

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

| EC | Interpersonal skills | UE 8JUPPN04 S8 Company | |
|---|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Give instructions, have them applied and verify their application (level 2) Develop your assertiveness within a team (level 2) Acquire autonomy Adapt to an international environment

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

| | | |
|---|---|---|
| ***EC 8JEPPN4*** | **2A Defense** | ***UE 8JUPPN04 S8 Company*** |

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

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**Academic year 2025-2026**
**Detailed curriculum 2025-2026 NRJ_FISA**

## Semester S9

| Code | Course Unit | ECTS | Code | Course | Coeff | *Teacher* | Vol | CM | TD | TP |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 9KEPPN11 | Advanced energy transfers | ? | *N. Rimbert* | **35** | 22 | 0 | 13 |
| | | | 9KEPPN13 | Sizing of energy systems | ? | *D. Netter* | **20** | 0 | 0 | 20 |
| | | | 9KEPPN14 | Electric power networks 3 | ? | *S. Pierfederici* | **30** | 18 | 4 | 8 |
| | | | 9KEPPN15 | Sources and means of storing electrical energy | ? | *S. Rael* | **20** | 5 | 0 | 15 |
| | | | 9KEPPN17 | Vision and Robotics | ? | *D. Wolf* | **30** | 15 | 15 | 0 |
| 9KUAPP01 | Advanced Methods for Energy Systems | **10** | 9KEPPN18 | Internet networks | ? | *YQ Song* | **20** | 10 | 0 | 10 |
| | | | ? | 9_4 Control in the face of transport and conversion challenges | 0,25 | *J. Kreiss* | **30** | 0 | 30 | 0 |
| | | | ? | 9_4 Nuclear automation and control design office | 0,25 | *J.-F. Pétin* | **30** | 6 | 2 | 22 |
| | | | ? | 9_1 Risk analysis and functional security | 0,25 | *N. Brinzei* | **30** | 18 | 4 | 8 |
| | | | ? | 9_1 Monitoring and Diagnostics | 0,25 | *S. Maza* | **30** | 20 | 10 | 0 |
| | | | 9KEPP111 | 9-2 Inverse Problems, Decompositions, Parsimony | 0,1667 | *R. Ranta* | **20** | 10 | 10 | 0 |
| | | | 9KEPP141 | 9_6 Analytical modeling and optimization of electrical machine | 0,25 | *D. Netter* | **30** | 0 | 0 | 30 |
| | | | 9KEPP143 | 9_6 Optimization and design of electrical machines | 0,25 | *N. Takorabet* | **30** | 16 | 2 | 12 |
| | | | 9KEPP181 | 9_10 P-HIL - tools and techniques | 0,25 | *E. Jamshidpour* | **30** | 10 | 0 | 20 |
| | | | 9KEPP182 | 9_10 P-HIL Project | 0,25 | *C.-H. Bonnard* | **30** | 0 | 10 | 20 |
| | | | ? | 9_14 Materials Science | 0,1667 | *M.Bordron* | **20** | 8 | 4 | 8 |
| | | | ? | 9_14 Mechanical behavior of materials | 0,3333 | *C. Laurent* | **40** | 14 | 6 | 20 |
| | | | ? | 9_13 Methodology for characterizing | ? | *A. Labergue* | **20** | 20 | 0 | 0 |
| | | | ? | 9_13 Experimental characterization | ? | *G. Pernot* | **20** | 0 | 0 | 20 |
| 9KUAPP29 | Specializations for energy systems | **8** | ? | 9_13 Numerical simulations and applications | ? | *O. Caballina* | **20** | 0 | 0 | 20 |
| | | | 9KEPPN21 | English Interacting Professionally | 1 | *C. Corringer* | **24** | 0 | 24 | 0 |
| | | | 9KEPPN25 | Validation of international experience | pass/fail | *L. Traut* | **1** | 0 | 1 | 0 |
| 9KUAPP02 | Humanities 5 | **2** | 9KEPPN24 | Management | pass/fail | *F. Temsamani* | **6** | 0 | 6 | 0 |
| | | | | Technical competence | | | | | | |
| | | | | Methodological competence | | | | | | |
| | S9 Company | **10** | | Interpersonal skills | | | | | | |

| EC 9KEPPN1 | Advanced energy transfers | UE 9KUAPP01 Advanced Methods for Energy Systems | N. Rimbert |
|---|---|---|---|

**Total hours : 35**
**Lecture hours : 22**
**Tutorials hours : 0**
**Practical/lab hours : 13**

Objective

The objective of this course is to provide ENSEM engineers with the necessary skills to understand the waste heat recovery techniques currently being developed in the industrial environment. A strong emphasis is placed on the sizing methods of heat exchangers, which are ubiquitous in industry. We will mainly discuss single-phase exchangers, but a brief extension of the methods presented to the important cases of condensers and evaporators will conclude this section.

Skills acquired

Sizing a heat exchanger, choice of method, order of magnitude. Introduction to phase change exchangers (evaporators, condensers).

Prerequisites

Fluid mechanics (fundamental, turbulence and boundary layer, etc.). Heat transfer (thermal boundary layer, film temperature, etc.). Fundamental thermodynamics.

Assessment

The assessment is made for the exchanger part via a final exam to which is added a design office report and a Matlab practical work note and the practical work notes in the thermal room.

Teaching program

Heat exchanger (N. Rimbert) 1- Introduction to heat exchangers 2- Sizing of co-current and counter-current exchangers using the NUT and DTLM method 3- Useful correlations in heat transfer in exchangers 4- Extension of the NUT and DTLM method to other exchanger configurations 5- Numerical modeling of a heat exchanger with Matlab 6- Case of evaporators and condensers Three practical exercises in the thermal room are planned (co-current and counter-current exchanger, cross-flow exchanger and efficiency of a fin)

| | | | |
|---|---|---|---|
| ***EC 9KEPPN1*** | **Sizing of energy systems** | ***UE 9KUAPP01 Advanced Methods for Energy Systems*** | ***D. Netter*** |

**Total hours : 20**
**Lecture hours : 0**
**Tutorials hours : 0**
**Practical/lab hours : 20**

Objective

Know how to optimally size Electrical Engineering systems from an energy and economic point of view.

Skills acquired

Missing information

Prerequisites

Basics of electricity and electromagnetism from S5, basics of numerical analysis from S6.

Assessment

Case study and simulation to study and size energy devices

Teaching program

Missing information

| | | | |
|---|---|---|---|
| ***EC 9KEPPN1*** | **Electric power networks 3** | ***UE 9KUAPP01 Advanced Methods for Energy Systems*** | ***S. Pierfederici*** |

**Total hours : 30**
**Lecture hours : 18**
**Tutorials hours : 4**
**Practical/lab hours : 8**

Objective

Introduce the current standards for electrical networks. Propose models of network components, and implement all necessary measures to ensure network quality (compliance with standards). Conversion chains allowing the injection of energy into the network from renewable energy (photovoltaic and wind power installations) as well as the regulatory constraints imposed on them will be studied.

Skills acquired

Apprentices will have skills in network modeling, on conversion chains associated with renewable energy and on the main components of electrical networks.

Prerequisites

Electricity networks 1&2

Assessment

Grade 1 = test 1 grade Grade 2 = project grade Grade 3 = average of practical work grades Final grade = 0.3*grade 1+0.4*grade 2+ 0.3*grade 3

Teaching program

Quality of electrical energy networks: assessment of compliance with currently applicable standards, concept of active filtering in networks (adjustment of active and reactive power, FACTS and STATCOM will be presented) - photovoltaic conversion chain: modeling of photovoltaic cells/panels, principle of power extraction (usual MPPT algorithms of the P&O type, Incremental Conductance, etc.), case of power injection on the single-phase and three-phase network (photovoltaic power plants) - wind conversion chain: principle of power extraction, aerodynamic modeling, power conversion chain for synchronous generation (magnet synchronous machine) and asynchronous generation (asynchronous machine - MADA)

| | | | |
|---|---|---|---|
| ***EC 9KEPPN1*** | **Sources and means of storing electrical energy** | ***UE 9KUAPP01 Advanced Methods for Energy Systems*** | ***S. Rael*** |

**Total hours : 20**
**Lecture hours : 5**
**Tutorials hours : 0**
**Practical/lab hours : 15**

Objective

Knowledge of the principles of sources and means of storage for electrical energy

Skills acquired

Knowledge of the operating principles and constraints of photovoltaic generators, fuel cells, and associated storage devices (batteries, supercapacitors). Static and dynamic characterization methods for photovoltaic generators and fuel cells. Implementation, energy management, and hybridization.

Prerequisites

module S5 "Electrical circuits" module S6 "Power electronics" module S7 "Power electronics 2"

Assessment

5 practical work reports

Teaching program

During teaching sessions with a predominantly experimental approach, during which the theoretical elements necessary for understanding and analyzing phenomena will be presented, the apprentice will study in situ the operation of fuel cells, photovoltaic generators, and associated storage devices. Using his knowledge of electrical engineering, particularly power electronics, he will focus on implementing these particular generators in association with storage elements, and on managing their energy flows using appropriate algorithms.

| EC 9KEPPN1 | Vision and Robotics | UE 9KUAPP01 Advanced Methods for Energy Systems | D. Wolf |
|---|---|---|---|

**Total hours : 30**
**Lecture hours : 15**
**Tutorials hours : 15**
**Practical/lab hours : 0**

Objective

Acquire the basic concepts of computer vision and robotics.

Skills acquired

Ability to establish specifications for robotics and computer vision

Prerequisites

ENSEM Signal Processing Course

Assessment

Grading of work completed in tutorial sessions

Teaching program

Robotics Functional diagram of a robot Classification of robots Examples of robots Application sectors Articulated mechanical systems (AMS) Attitude of a reference in space Geometric models of AMS Generation of movements Control Image processing Image sensors and vision systems Point processing Logical or arithmetic processing Transfer functions Statistical analysis – thresholding Digital filtering of images Segmentation

| | | | |
|---|---|---|---|
| ***EC 9KEPPN1*** | **Internet networks** | ***UE 9KUAPP01 Advanced Methods for Energy Systems*** | ***YQ Song*** |

**Total hours : 20**
**Lecture hours : 10**
**Tutorials hours : 0**
**Practical/lab hours : 10**

Objective

Smart grids and microgrids increasingly rely on real-time data communication for monitoring, control, and optimization tasks. This communication is based on Internet technology. This course presents the fundamental concepts of Internet networks: the OSI model, local networks (e.g., Ethernet), Internet protocols (IP, ICMP, ARP DHCP, TCP, UDP, DNS), the principle of IP routing, as well as the development of communicating applications (client-server) via sockets in Python.

Skills acquired

- Knowledge of the principles of how the Internet works - Know how to configure workstations and routers to install a routed network - Know how to develop communicating applications using the client-server model (in Python)

Prerequisites

Transmission of information, Algorithms and programming.

Assessment

Network configuration and distributed application development skills are assessed through practice.

Teaching program

Courses: - OSI model, TCP/IP model, Industrial networks - MAC protocols (eg, ALOHA, CSMA, Ethernet) - Internet protocols (IP, ICMP, ARP, DHCP, DNS, TCP/UDP) - IP routing - Client-server communicating applications with socket Practical work: - Protocol analysis with Wireshark - Socket programming - Local networks (hub and switch) and IP routing (router)

| EC ? | 9_4 Control in the face of transport and conversion challenges | UE 9KUAPP29 Specializations for energy systems | J. Kreiss |
|---|---|---|---|

**Total hours : 30**
**Lecture hours : 0**
**Tutorials hours : 30**
**Practical/lab hours : 0**

Objective

In the form of design offices, this EC aims to solve three concrete problems: - optimize energy in a power converter - understand the success of estimating the position of a GPS - control the behavior of a wind turbine facing a disturbed wind.

Skills acquired

Deepen and diversify your toolbox in advanced control techniques: optimal control, Kalman observer, sliding mode control - Develop the ability to analyze specifications to identify and select the most suitable control method - Acquire a complete engineering approach, ranging from the formalization of a problem to its modeling, resolution and validation by simulation

Prerequisites

Knowledge acquired in ENSEM 1A common core training: - Automatic 1A (S5)

Assessment

The evaluation will be based on the work provided during the sessions and any deliverables (reports, presentations) for each design office.

Teaching program

Design offices (in the form of lectures/tutorials) on computer machines using Matlab: - BE1: Optimal control for a power converter (8 hours) - BE2: Kalman observer for a positioning system (10 hours) - BE3: Sliding mode control of a wind turbine (12 hours)

| EC ? | 9_4 Nuclear automation and control design office | UE 9KUAPP29 Specializations for energy systems | J.-F. Pétin |
|---|---|---|---|

**Total hours : 30**
**Lecture hours : 6**
**Tutorials hours : 2**
**Practical/lab hours : 22**

Objective

The objective of this EC is to present some tools for modeling and numerical simulation of SEDs. The learning is carried out around case studies: piloting a flexible production cell for the tool and control-command of a nuclear power plant using tools widely used in the industrial control-command community (ControlBuild from Dassaut System and SCADE from ANSYS.

Skills acquired

At the end of this course, students will be able to: - understand all types of digital simulation tools for SEDs and formal verification - model and simulate a system characterized by discrete event systems-type behavior, - design and simulate the control of an discrete event systems - analyze and formally verify its properties, particularly those relating to safety

Prerequisites

This EC complements the theoretical foundations acquired in the 2A Discrete Event Systems Modeling EC.

Assessment

Digital restitution of the work relating to the two design offices

Teaching program

lecture: modular design of industrial automation, emulation of operational parts, digital simulation and formal verification of properties. Design offices: - Nuclear control and command (2 elementary systems of a "lego" power plant supplied by EDF). - Flexible Production Systems

| EC ? | 9_1 Risk analysis and functional security | UE 9KUAPP29 Specializations for energy systems | N. Brinzei |
|---|---|---|---|

**Total hours : 30**
**Lecture hours : 18**
**Tutorials hours : 4**
**Practical/lab hours : 8**

Objective

This module provides the knowledge needed to analyze, model, and assess the risks to which critical energy systems are exposed, as well as the means of prevention or protection that must be implemented. The target systems are the control and security systems of energy systems: nuclear power plants, offshore oil extraction platforms, and hydrogen storage or transport systems.

Skills acquired

At the end of this EC, students will be able to: • Know how to analyze and model control-command architectures and the associated risks • Know how to analyze and evaluate safety instrumented systems (SIS) in accordance with current norms and standards

Prerequisites

General knowledge of the operation of mechanical, hydraulic, electrical, electronic and automated systems

Assessment

• Continuous monitoring: case studies and simulations to model, evaluate and analyze safety instrumented systems with a view to their qualification according to the IEC 61508 standard. • Evaluation: 1 test and 2 reports.

Teaching program

Risk analysis (12h lecture) • Qualitative approaches: APR (Preliminary Risk Analysis), AMDEC, HAZOP • Principles of design of safe systems (separation, independence, defense in depth, etc.) • Design of control and security architectures used in nuclear power plants • Risk analysis and operational safety of programmed systems 2. Functional safety (2h lecture and 4h lab work) • Safety instrumented systems (SIS) implemented for risk reduction in the nuclear industry, the oil industry, hydrogen storage and transport systems • IEC 61508 standard (SIL level, PFD, PFH, etc.) and probabilistic assessment of SIS 3. Modeling and assessment approaches for reconfigurable multi-state systems (4h lecture, 4h tutorial and 4h lab work) • Analytical approach: stochastic Petri nets (RdPS): rules behavior, equivalent Markovian stochastic processes, evaluation of risk indicators (reliability, availability, PFD, PFH, etc.) • Simulation approach: Stochastic Activity Networks (SAN)

| EC ? | 9_1 Monitoring and Diagnostics | UE 9KUAPP29 Specializations for energy systems | S. Maza |
|---|---|---|---|

**Total hours : 30**
**Lecture hours : 20**
**Tutorials hours : 10**
**Practical/lab hours : 0**

Objective

Industrial systems are subject to failures that can lead to performance losses, safety issues, or even total shutdown of the installation. It is therefore essential to be able to detect the occurrence of faults in these systems, in order to control the resulting risks. Diagnosis is defined as the operation to detect a fault, or a failure state, and to locate its origin. Performing a diagnosis consists of comparing the instantaneous information from the system to a reference or a model representing normal and/or dysfunctional operation. The objective of the module is to present methods for detecting, locating and characterizing malfunctions of industrial systems and/or its components, whether they are described by algebraic, differential or discrete event models.

Skills acquired

Skills: - From a set of measurements or events, from recordings or acquired in real time, be able to detect a failure state or a defect and remedy it if necessary. - Be able to implement diagnostic schemes to monitor the operation of an industrial system. - In the case of a discrete dynamics system: analyze its behavior through the sequences of events it produces to diagnose the occurrence of defects and more generally the occurrence of unobservable events (absence or failure of sensors). - Concrete case studies: (1) Water distribution network; (2) air conditioning system.

Prerequisites

Knowledge acquired in the ENSEM 1A and 2A core curriculum: - Basic elements of linear algebra, matrix calculus, basic linear automation (1st Year). - Basic elements of discrete event systems (a reminder of languages and state automata will be given)

Assessment

Missing information

Teaching program

Lectures Part (1) - Continuous systems (12h) modeled by algebraic or differential equations - Model-based monitoring of industrial processes - Concept of redundancy (hardware redundancy, analytical redundancy, voting method) - Approach to parity space (static and linear dynamic cases) - Generation of residuals using state observers, structuring of residuals Part (2) - Discrete event systems (8h) Discrete dynamic systems - Reminders on SEDs, languages and automata - Concept of unobservable events, observed sequence, diagnosable sequence. - State estimator of an discrete event systems described by an automaton - Diagnosis of unobservable events by: automata, chronicles, residuals and RdPs. Tutorials, part of which is on a computer machine Part (1): 6h of tutorial - Application to a portable water distribution network: monitoring by observer bench. - Application of sensor fault detection and localization (static and dynamic parity space). - Application to the estimation of actuator faults (observer with unknown input). Part (2): 4 hours of tutorial - Application to an air conditioning system: automaton-based diagnosis with implementation on “Supremica” synthesis software.

| EC 9KEPP11 | 9-2 Inverse Problems, Decompositions, Parsimony | UE 9KUAPP29 Specializations for energy systems | R. Ranta |
|---|---|---|---|

**Total hours : 20**
**Lecture hours : 10**
**Tutorials hours : 10**
**Practical/lab hours : 0**

Objective

This module aims to present the most suitable theoretical means and methodologies for efficiently processing and analyzing measurements acquired on physical processes. More specifically, these are model inversion techniques, decomposition and partial reconstruction (and therefore extraction of relevant information) from these measurements.

Skills acquired

- Ability to formalize a measurement in the form of a direct problem / inverse problem - Know-how on the implementation of inversion algorithms and on the interpretation of results

Prerequisites

Knowledge acquired in the ENSEM 1A and 2A core curriculum: - Basic notions of linear algebra (matrix calculus, eigenspace, projection) (S5) - Basic notions of optimization (S6) - Basic elements of probability and statistics (S7)

Assessment

Practical work on a computer machine using Matlab

Teaching program

Three approaches dedicated to linear systems will be presented: the first integrates knowledge on the physics of the measured phenomenon in the form of a model, the objective being to invert this model in order to find the causes (sources) at the origin of the measurement. A second approach proposes to extract the relevant information directly from the data, either by finding a generic model linking the sources to the measurements (optimal filter / Wiener / RLS), or by exploiting their redundancy (PCA, whitening, source separation). Lectures: - Decomposition on physical model (inverse problems) - Regularization, minimum norm ... - Sparse reconstruction, iterative regression - Decompositions from data - Wiener filtering, adaptive filtering - Elements of Source Separation Keywords: inverse problems, greedy algorithms, Wiener filtering, source separation

| EC 9KEPP14 | 9_6 Analytical modeling and optimization of electrical machines | UE 9KUAPP29 Specializations for energy systems | D. Netter |
|---|---|---|---|

**Total hours : 30**
**Lecture hours : 0**
**Tutorials hours : 0**
**Practical/lab hours : 30**

Objective

The objective of this module is to propose a methodology for the analytical dimensioning of an electrical machine. Once the model is built, it will be completed by an optimization process that will allow us to meet design specifications (for example, finding the dimensions of the machine that will minimize the mass for a given operating point). We will implement a project-based teaching method where teamwork and autonomy will be highly valued.

Skills acquired

Skills acquired following this module: • Know how to analyze technical documents to calculate the parameters of the equivalent electrical diagram of the asynchronous machine. • Know how to build a sizing tool (Matlab or Python) from analytical formulas and design a user-friendly graphical interface. • Pose an optimization problem to find a machine configuration meeting specifications.

Prerequisites

Electrical machines S6 and S7, General electrical engineering S5.

Assessment

No final review. Deliverables will be required (sizing program, user manual, technical documentation, and one quote). The pages of the documents will be labeled to individualize the evaluation.

Teaching program

Practical work 30 hours of practical work 21 hours of practical work for establishing the analytical model. 9 hours of practical work for optimizing the machine

| EC 9KEPP14 | 9_6 Optimization and design of electrical machines | UE 9KUAPP29 Specializations for energy systems | N. Takorabet |
|---|---|---|---|

**Total hours : 30**
**Lecture hours : 16**
**Tutorials hours : 2**
**Practical/lab hours : 12**

Objective

This module focuses on the modeling and design of electrical machines, with an emphasis on numerical techniques based on the finite element method. A significant portion is devoted to winding techniques for alternating current machines. Project-based work is implemented in the form of a sizing and design project for an electrical machine (design office).

Skills acquired

Skills acquired following this module: • Winding of alternating current machines • Pre-dimensioning and design of machines • Numerical modeling by finite elements – Free software and commercial software

Prerequisites

Electrical machines S6 and S7, General electrical engineering S5

Assessment

• Written exam • Project mode work: Machine sizing report for individual specifications

Teaching program

Course 16h Winding of AC machines Digital modeling techniques of machines (Synchronous and Asynchronous) Pre-dimensioning and design of permanent magnet machines Introduction to commercial software (FluxMotor) Tutorials 2h tutorial Content: 1 tutorial of 2h: Design and simulation of windings Practical work 12h lab work Content: 4 sessions of 3h. lab work 1 and 2: FEMM: Synchronous machine with permanent magnets lab work 3 and 4: FluxMotor: Synchronous machine with permanent magnets and asynchronous machine

| EC 9KEPP18 | 9_10 P-HIL - tools and techniques | UE 9KUAPP29 Specializations for energy systems | E. Jamshidpour |
|---|---|---|---|

**Total hours : 30**
**Lecture hours : 10**
**Tutorials hours : 0**
**Practical/lab hours : 20**

Objective

This module aims to decipher the key elements of a “Power Hardware-In-the-Loop” (P-HIL) simulation with the presentation of simulation tools that allow the integration of physical devices (control/command and/or actuator) in a simulation loop via weak signals from sensors (current, voltage, speed, etc.). Emphasis will be placed on the experimental implementation and understanding of the P-HIL methodology through practical work. This EC aims to acquire essential concepts that can be explored in greater depth with the P-HIL Project EC (B18-S9-2).

Skills acquired

Modeling and exploitation of models of the systems tested and/or their environment Instrumentation and measurements Planning and implementation of tests using the P-HIL method aimed at validating: -The correct functioning of the tested equipment or their settings and control laws. -Verification of the behavior of a model through a targeted measurement campaign.

Prerequisites

No prerequisites.

Assessment

Assessment method: Individual practical work reports, no final exam

Teaching program

No prerequisites Course 10h: • Introduction to existing simulation tools and techniques (notably dSPACE). • Implementation of a P-HIL simulation tool: Deciphering the key steps. Practical work 20h Practical work: • Content: 5 practical work sessions of 4h. • Practical work 1: Introduction to P-HIL: Coupling simulation and simple physical devices. • Practical work 2: Three-phase systems and measurement/acquisition/integration of analog signals. • Practical work 3: Quality of electrical energy and power analysis for electrical networks. • Practical work 4: Protection equipment, selection, settings and verification. • Practical work 5: Detection of faults in converters, renewable energy application.

| EC 9KEPP18 | 9_10 P-HIL Project | UE 9KUAPP29 Specializations for energy systems | C.-H. Bonnard |
|---|---|---|---|

**Total hours : 30**
**Lecture hours : 0**
**Tutorials hours : 10**
**Practical/lab hours : 20**

Objective

This module aims to apply all the elements covered in EC1 (B18-29-1) with the implementation of “Power Hardware-In-the-Loop” (P-HIL) simulation tools within the framework of a tutored project (to be carried out in groups). The topics are scalable, semi-open and are to be defined with the teachers of the electrical engineering department at the beginning of the session. The latter will draw on the knowledge acquired by the students in their previous courses. It is expected that the students implement project management methods and tools to best plan and prepare their project, integrate simulation models and proceed with the instrumentation of the equipment to be tested, in order to carry out their tests with the P-HIL method.

Skills acquired

The skills acquired following this module complement those of EC1: + Modeling and exploitation of models of the systems tested and/or their environment. + Instrumentation and measurements of equipment. + Planning and implementation of tests with the P-HIL method aimed at validating: - The correct functioning of the equipment tested or their settings and control laws - Verification of the behavior of a model through a targeted and pre-defined measurement campaign. + Use of project management methods and tools.

Prerequisites

No prerequisites.

Assessment

Assessment method: Specifications, project report, individual assessment by oral presentation of the preliminary project and the project, no final exam.

Teaching program

tutorial 10h: • Preparation and analysis of the project (technical and practical aspects) • Application of project management tools These steps allow you to become familiar with the project, ensure its organization within the group, guarantee its monitoring and reorganization according to its evolution. Practical work 20h lab work: Implementation of the project.

| EC ? | 9_14 Materials Science | UE 9KUAPP29 Specializations for energy systems | M.Bordron |
|---|---|---|---|

**Total hours : 20**
**Lecture hours : 8**
**Tutorials hours : 4**
**Practical/lab hours : 8**

Objective

The parts and structures that surround us are primarily made of materials, whose effective properties depend on the organization and properties of matter at the microscopic scale. The objective of this EC is to enable the student to make the link between the microstructure of a material and its effective behavior, and to understand which microscopic characteristics give it its properties. The objective is also to understand how to select the best material for a given application, or modify its mechanical properties by adjusting its composition and microstructure.

Skills acquired

This EC will enable you to acquire the following skills: - Appreciate the link between the atomic and microstructure scales and the mechanical properties of solids; - Know how to read an equilibrium phase diagram of alloys and know how to predict the corresponding microstructure; - Know how to observe and characterize the microstructure of a material - Know certain ways of improving the mechanical properties of materials

Prerequisites

Common core knowledge in continuous media mechanics and applied mechanics.

Assessment

The final assessment of the module will be based on a written assessment and on reports of the practical work that has been carried out.

Teaching program

The fundamental knowledge related to materials science will be covered in lectures and will mainly concern: - the classification of different classes of materials and different types of bonds at the atomic scale in solids; overall review of the properties of materials - the behavior and characteristics of a perfect crystal - defects in pure and real materials, their classification, their interactions - the link between these characteristics and the apparent mechanical behavior - the evolution of these properties over time and the possibilities of improving them The tutorials will focus on basic crystallography exercises and the reading of phase diagrams. In practical work, students will observe under an optical microscope materials that have undergone different heat treatments (ovens and quenching) and will be able to measure their mechanical properties (hardness, rupture energy, elastic limit) using the testing machines at their disposal

| EC ? | 9_14 Mechanical behavior of materials | UE 9KUAPP29 Specializations for energy systems | C. Laurent |
|---|---|---|---|

**Total hours : 40**
**Lecture hours : 14**
**Tutorials hours : 6**
**Practical/lab hours : 20**

## Objective

In most industrial applications (aeronautics, transport, storage, mechanical construction, etc.), we seek to optimize the mechanical properties of structures and/or anticipate their mechanical behavior or their lifespan. This EC aims to provide a solid foundation for understanding the different types of mechanical behavior offered by commonly used materials, ranging from their characterization to the mathematical modeling of this behavior in order to feed numerical simulations to predict and improve the mechanical behavior of the structures studied, relying in particular on modules dedicated to the optimization of structures.

## Skills acquired

This EC will enable you to acquire the following skills: - Characterize the mechanical behavior of a material - Understand and classify the different mechanical behaviors - Predict and simulate these main behaviors - Predict the lifespan of a part or structure - Understand the specificities of the behavior of composite materials

## Prerequisites

Common core knowledge in continuous media mechanics and applied mechanics.

## Assessment

The final assessment of the module will be based on a written assessment and on reports of the practical work that has been carried out.

## Teaching program

The many notions covered during this EC will be done through the learning of fundamental concepts, the application in tutorial around concrete problems, and the acquisition of technical know-how in the context of experimental or numerical practical work. The fundamental knowledge related to the mechanical behavior of materials will be covered in lectures and will mainly concern: - isotropic and hyperelastic elastic behavior - plastic behavior - viscoelastic behavior - stress concentration and lifetime - special case of anisotropic elastic behavior: applications to composites - the development and behavior of the main types of composite materials The TDs will focus on exercises dimensioning parts or structures showing different types of mechanical behavior and the calculation of their lifetime. In practical work, students will have the opportunity to observe some of these mechanical behaviors using the testing machines at their disposal, and to transpose their knowledge into calculation codes in order to simulate the mechanical behavior of parts or structures.

| EC ? | 9_13 Methodology for characterizing | UE 9KUAPP29 Specializations for energy systems | A. Labergue |
|---|---|---|---|

**Total hours : 20**
**Lecture hours : 20**
**Tutorials hours : 0**
**Practical/lab hours : 0**

Objective

This course is an introduction to advanced scientific metrology specific to fluid mechanics and heat and mass transfer. Based on several methods, the objectives are, on the one hand, to provide the physical and theoretical elements on which the principle of these methods is based and, on the other hand, to transmit the critical practices allowing to evaluate and choose the experimental method(s) adapted to the situations of interest.

Skills acquired

At the end of this course, students will have acquired solid theoretical skills on the operation of advanced metrology used in industry and developed in laboratories for the characterization of transfers. They will be able to develop an experimental approach by choosing the appropriate tools and methods as well as to plan experiments before their practical implementation. They will have the necessary tools for analyzing feedback.

Prerequisites

EC Thermodynamics (S5) EC Fluid Mechanics and Applications (S6), EC Introduction to Thermal Transfers (S7) Block Fluid Energy Transfers and Conversion (S8)

Assessment

The assessment will consist of a presentation on a method of choice where, in addition to the theoretical aspects, the student's critical skills will be assessed.

Teaching program

A. Introduction to thermal and fluid metrology B. Principles and description of some techniques - Laser optical diagnostic methods: PIV and LIF - Magnetic resonance imaging methods: NMR - Heat flow measurements: Infrared thermography - Local probe microscopy: Atomic Force Microscope (AFM) and scanning thermal microscope (SThM)

| EC ? | 9_13 Experimental characterization | UE 9KUAPP29 Specializations for energy systems | G. Pernot |
|---|---|---|---|

**Total hours : 20**
**Lecture hours : 0**
**Tutorials hours : 0**
**Practical/lab hours : 20**

Objective

The objectives of this EC are, on the one hand, to put into practice the theoretical skills and techniques covered in the EC "Methodology for characterization" and on the other hand, to allow students to become familiar with cutting-edge metrologies and experimental techniques for the characterization and measurement of properties in the broad sense.

Skills acquired

Students will acquire a solid understanding of certain experimental techniques (laser velocimetry, local probe microscopy (AFM), nuclear magnetic resonance, infrared camera, laser-induced fluorescence) during practical sessions. The discovery of these techniques and their metrologies will enrich the knowledge base in the fields of fluid mechanics and heat transfer as well as expand the experimental skills necessary for future engineers.

Prerequisites

Fluid mechanics Heat transfer EC of Methodology to characterize

Assessment

The assessment will take the form of 15/20 minute oral presentation(s) in front of a jury composed of speakers from this EC.

Teaching program

This EC takes place in the form of 5 sessions of 4 hours of Practical Work in groups of 3 or 4 students. Each of these sessions will focus on one of the techniques covered in the EC "Methodology for characterization". The details of each theme are as follows: -Nuclear Magnetic Resonance (NMR) -Laser Velocimetry (PIV) -Laser Induced Fluorescence (LIF) -Local Probe Microscopy (AFM/SThM) -Infrared Camera.

| EC ? | 9_13 Numerical simulations and applications | UE 9KUAPP29 Specializations for energy systems | O. Caballina |
|---|---|---|---|

**Total hours : 20**
**Lecture hours : 0**
**Tutorials hours : 0**
**Practical/lab hours : 20**

Objective

This course complements the training in computational fluid mechanics by focusing on the validation of CFD simulations. Students will learn to verify their results: - by orders of magnitude, - by comparison with analytical or experimental references, - by applying good simulation practices (definition of specifications, mesh control, invariance tests and convergence analysis).

Skills acquired

Use a CFD simulation tool to solve an engineering problem, respecting good numerical practices. - Rigorously validate simulation results, based on order of magnitude calculations, comparisons with analytical or experimental data, convergence and mesh independence tests. - Interpret and use the results in an optimization, diagnostic or decision support process.

Prerequisites

Applied Fluid Mechanics (S6), Fluid Mechanics for Engineers (S8), Heat and Mass Transfer (S8), Finite Volume Methods

Assessment

The assessment will be based on a technical note to be written and a final oral presentation.

Teaching program

This module will take the form of a project carried out individually or in pairs. A list of topics will be proposed in resonance with the themes of the other EC courses in fluid mechanics and thermal engineering. Once the topic is chosen, the group will work during the 20 hours on the numerical implementation and resolution of the chosen physical case in Fluent. A critical analysis of the results will finalize the project. This work will require a bibliographic research, the consultation of the technical documentation of FLUENT to support the analysis of the results obtained.

| EC 9KEPPN2 | English Interacting Professionally | UE 9KUAPP02 Humanities 5 | C. Corringer |
|---|---|---|---|

**Total hours : 24**
**Lecture hours : 0**
**Tutorials hours : 24**
**Practical/lab hours : 0**

Objective

This EC consists of two professionally oriented modules: Interacting Professionally and Scientific Communication. The objective of the EC is to give students skills in business English and scientific English.

Skills acquired

-Skills in written and oral expression and comprehension related to an engineering career -International openness -Cultural openness -Teamwork

Prerequisites

Have reached a B2 level

Assessment

Continuous assessment (written work, oral participation) and final oral assessment at the end of each module.

Teaching program

The Interacting Professionally module aims to prepare students to apply for job offers in English, to work with foreign partners (awareness of the notion of intercultural communication) and to professional communication in English (meeting management, project presentation, negotiation). For the Scientific Communication module, the focus is on scientific communication in writing (report writing, abstract writing, concise technical English) and orally (describing processes, simplifying / rephrasing technical concepts, etc.).

| | | | |
|---|---|---|---|
| ***EC 9KEPPN2*** | **Validation of international experience** | ***UE 9KUAPP02 Humanities 5*** | ***L. Traut*** |

**Total hours : 1**
**Lecture hours : 0**
**Tutorials hours : 1**
**Practical/lab hours : 0**

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

| | | | |
|---|---|---|---|
| ***EC 9KEPPN2*** | **Management** | ***UE 9KUAPP02 Humanities 5*** | ***F. Temsamani*** |

**Total hours : 6**
**Lecture hours : 0**
**Tutorials hours : 6**
**Practical/lab hours : 0**

Objective

•Understand the management function within the company. •Acquire the basics of management and the managerial posture.

Skills acquired

•Know the role, main activities and skills required of a manager. •Develop your leadership as a manager.

Prerequisites

Basics of the business environment.

Assessment

Discharge

Teaching program

• 1 - Management in business: •Definition of management •Position and responsibility within the company (role, action and relationships) •The different types of management (interests, limits, and application) • 2 - The functions of the manager: •Role and posture •Skills and soft skills •Establishment of a hierarchical position •Setting objectives •Mobilizing resources (delegating and empowering, planning talent development) • 3 - Essential practices: •Intercultural management •Risk management •Conflict management •Conducting individual interviews

| EC | Technical competence | UE S9 Company | |
|---|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Master the different techniques of the functions of an engineer in the field of Energy

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

| EC | Methodological competence | UE S9 Company | |
|---|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Manage a project in all its dimensions Set objectives Prioritize activities and respect costs, deadlines and quality

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

| EC | Interpersonal skills | UE S9 Company | |
|---|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Lead a working group by calling on experts Take responsibility Negotiate externally

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

**ECOLE NATIONALE SUPERIEURE**
**D'ELECTRICITE ET DE MECANIQUE**
2, Avenue de la Forêt de Haye
54500 Vandoeuvre-lès-Nancy

**Academic year 2025-2026**
**Detailed curriculum 2025-2026 NRJ_FISA**

## Semester S10

| Code | Course Unit | ECTS | Code | Course | Coeff | *Teacher* | Vol | CM | TD | TP |
|---|---|---|---|---|---|---|---|---|---|---|
| 0KUAPP01 | S10 Company | **30** | | Report and defense 3A | 1 | | | | | |

| *EC* | **Report and defense 3A** | ***UE 0KUAPP01 S10 Company*** |
|---|---|---|

**Total hours :**
**Lecture hours :**
**Tutorials hours :**
**Practical/lab hours :**

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information