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

LORRAINE INP Ensem

Academic year 2025-2026
Detailed curriculum 2025-2026 NRJ_FISE

Semester S5

Code	Course Unit	ECTS	Code	Course	Coeff	Teacher	Vol	CM	TD	TP
			5JEPLN20	Mathematics for engineers	0,6	*A. Gueudin*	**32**	16	16	0
5JUPLN02	Tools for mathematics	**5**	5JEPLN21	Numerical Analysis 1	0,4	*?*	**20**	8	6	6
			5JEPLN10	continuum mechanics	0,5	*C. Laurent*	**30**	16	14	0
5JUPLN01	Foundations of mechanics	**5**	5JEPLN11	Thermodynamics	0,5	*G. Pernot*	**30**	16	14	0
			5JEPLN30	Fundamentals of Electrical Engineering	0,5	*F. Meibody*	**30**	14	10	6
5JUPLN03	Electricity 1	**5**	5JEPLN31	Electrical Circuits and Applications	0,5	*T. Boileau*	**30**	12	10	8
			5JEPLN40	Modeling of signals and systems	0,4	*V. Louis-Dorr*	**23**	9	4	10
			5JEPLN41	Logical and discrete event systems	0,1	*J.-F. Pétin*	**7**	4	3	0
5JUPLN04	Information and computer sciences 1	**5**	5JEPLN42	Algorithms and programming	0,5	*?*	**30**	7	5	18
			5JEPLN50	English	0,5	*C. Corringer*	**24**	0	24	0
			5JEPLN51	Modern languages 2	0,5	*A. Quesada*	**24**	0	24	0
5JUPLN05	Languages 1	**5**	5JEPLN52	Validation of the French language clearance certificate	pass/fail	*A. Quesada*	**1**	0	1	0
			5JEPLN60	Business environment	0,3	*F. Temsamani*	**20**	14	6	0
			5JEPLN64	Electrical Accreditation and Health at Work	pass/fail	*T. Boileau*	**8**	8	0	0
			5JEPLN68	CSR 1	pass/fail	*V. Louis-Dorr*	**11**	2	9	0
			5JEPLN67	Industrial conferences	pass/fail	*P. Villette*	**6**	6	0	0
			5JEPLN61	Communication	0,3	*A. Thimon*	**16**	0	16	0
			5JEPLN62	Project management	0,4	*J.-C. Marpeau*	**18**	2	16	0
5JUPLN06	General Training 1	**5**	5JEPLN63	1st year project	pass/fail	*J.-C. Marpeau*	**30**	0	0	30

Total hours : 32
Lecture hours : 16
Tutorials hours : 16
Practical/lab hours : 0

Objective

This mathematics module is particularly dedicated to standardizing the level of students entering ENSEM. The first new elements are then taught progressively to introduce students to more advanced mathematics. These concepts are fundamental and among the first to be used in the school's other CFSs.

Skills acquired

During this teaching, students will: - Improve their reasoning skills, - Master the mathematical concepts useful for engineering sciences.

Prerequisites

The prerequisites are the knowledge of mathematics acquired during the two years of MP/PC/PSI preparatory classes (program appearing in the Official Bulletin of May 30, 2013).

Assessment

Validate skills in the form of a written test

Teaching program

The program covers knowledge reminders and an introduction to basic mathematics for the engineer as a tool. Continuity; sequences and series of functions Differential calculus; Integral calculus (curvilinear, Stokes' theorem, flux-divergence theorem); Linear algebra (reminders); Differential equations; Partial differential equations The Laplace transform; Fourier series; The Fourier transform of functions. Modeling of physical problems for Engineering Sciences. The applications in tutorial are: 1) mastery of integral calculus (in dimensions 1, 2 and 3) and its applications to physics problems; 2) mastery of solving ODEs and PDEs by direct methods or by using the Laplace transform/Fourier transform/Fourier series, applications to physics problems.

EC 5JEPLN2.	**Numerical Analysis 1**	*UE 5JUPLN02 Tools for mathematics*	*?*

Total hours : 20
Lecture hours : 8
Tutorials hours : 6
Practical/lab hours : 6

Objective

Numerical Analysis is taught through two complementary ECs: Numerical Analysis 1 in semester 5 and Numerical Analysis 2 in semester 6. This course provides an introduction to the various techniques for numerically solving problems encountered in engineering sciences. Its objective is to provide the resolution techniques in numerical mathematics, the associated algorithms and their computer implementation (under Matlab) for the simulation of deterministic problems.

Skills acquired

Students are led, step by step, towards understanding numerical mathematics useful in their engineering training. Individual problem solving should lead students to demonstrate greater autonomy. In particular, at the end of this course, students should be able to analyze the problem posed, determine the most appropriate numerical method to solve the problem, implement this method and analyze the results obtained.

Prerequisites

good command of the "basic" mathematical concepts (analysis, algebra, etc.) acquired during the first two years of higher education and within the framework of the "Mathematics for Engineers" module is required. Similarly, a mastery of computer tools, algorithms, and basic programming is assumed.

Assessment

Validate skills through digital practical work reports and a written test.

Teaching program

Errors in numerical analysis; - Numerical resolution of nonlinear equations; - Interpolation and polynomial approximation; - Numerical derivation and integration;

EC 5JEPLN1(	continuum mechanics	UE 5JUPLN01 Foundations of mechanics	C. Laurent

Total hours : 30
Lecture hours : 16
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 indeformable solid), the kinematics of a continuum is described, then the internal forces within this continuum as well as an introduction to the constitutive laws 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 a one-hour test in November (coefficient 0.25) and a two-hour exam in January (coefficient 0.75), 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 Continuum mechanics: definition, applications Kinematics of continuum: representation of motion and strains Dynamics of continuum: representation of internal forces, properties of the stress tensor Application to solids : the isotropic linear elastic solid Application to fluids 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: Strain fields: crushing of a solid tire tutorial 4: Stress analysis: 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

Total hours : 30
Lecture hours : 16
Tutorials hours : 14
Practical/lab hours : 0

Objective

The EC of macroscopic 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 the 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 a basic understanding of photovoltaic and thermoelectric conversion.

Prerequisites

Basics of thermodynamics at CPGE, IUT or L2 level.

Assessment

Mid-term written test lasting 1 hour (25%) + Final written exam lasting 2 hours (75%).

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

Total hours : 30
Lecture hours : 14
Tutorials hours : 10
Practical/lab hours : 6

Objective

This module provides the basics of external modeling of electrical systems using elements representing the physical phenomena observed in its components. 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

Physics program for preparatory classes for the grandes écoles.

Assessment

Written exams assess the theoretical knowledge acquired on modeling and determining the performance of electrical systems in steady sinusoidal conditions. In addition, the experimental skills acquired during practical work are also assessed by grading the reports produced on identifying the parameters of single-phase and three-phase transformer models and measuring their performance.

Teaching program

Single-phase and three-phase electrical systems (6h 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 steady sinusoidal mode. Study three-phase systems in sinusoidal mode using symmetrical components. - Magnetic circuits (2h lecture, 2h tutorial): Modeling magnetic circuits using permeance networks. Modeling and sizing magnetically coupled inductances. - Single-phase transformers (3h lecture, 2h tutorial, 3h 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, 2h tutorial, 3h 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 5JEPLN3.	Electrical Circuits and Applications	UE 5JUPLN03 Electricity 1	T. Boileau

Total hours : 30
Lecture hours : 12
Tutorials hours : 10
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

Proficiency in the study of electrical circuits in transient conditions. Proficiency in the simulation of transient conditions using Matlab Simulink using state-of-the-art equations. Proficiency in the method for studying diode assemblies. Knowledge of the basic concepts of analog electronics (AOP), the concepts of input impedance and 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 Matlab Simulink modeling - Diodes - AOP and AOP assemblies - Transistors lab work - Oscilloscope - Differential Amplification - Class B and Class D Amplifier

Total hours : 23
Lecture hours : 9
Tutorials hours : 4
Practical/lab hours : 10

Objective

The objective is to train students in the time and frequency analysis of signals and the analysis of linear and translation-invariant systems. This course provides an introduction to basic signal processing tools. Typical applications are the functional analysis of the instrumentation chain.

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. This know-how is on the one hand theoretical and on the other hand it is applied to real processes in practical work. The skills acquired are the bases of continuous systems analysis and signal processing engineering.

Prerequisites

First and second order linear physical systems and linear differential equations

Assessment

Assessment of the student's ability to manipulate theoretical models to respond to a process behavior study and to analyze signals. Continuous assessment and the end-of-semester exam assess the ability to manipulate theoretical modeling tools. In practical work, we assess the students' ability to understand a real system and compare the performance of the model with real behavior.

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 CM8: Analog filtering: concept of noise in signals, noise generated in electronic components, signal-to-noise ratio, modeling of narrowband noise. Impulse and step response of the first and second order. Analysis and synthesis of passive and active analog filters, template, first and second order, harmonic response, Bode diagram, polynomial approximations of Butterworth, Tchebychev, Bessel. CM9: Application of analog amplitude modulation-demodulation: Interest of modulation in information processing. 4 1-hour tutorials Tutorial 1: Convolutional system & Fourier transform Tutorial 2: Template and synthesis of a filter Tutorial 3: Modulation - Demodulation in the instrumentation chain Tutorial 4: Study of the same system using different modeling tools: differential equation, convolution, transfer function 3 Practical work Practical work 1 identification of 1st and 2nd order system Practical work 2 Study and analysis of filtering in electronic CAD Practical work 3 Study of an instrumentation chain the dynamometer

Total hours : 7
Lecture hours : 4
Tutorials hours : 3
Practical/lab hours : 0

Objective

The objective of this EC is to introduce students to the theoretical foundations of Logic and Discrete Event Systems.

Skills acquired

At the end of this course, students will be able to model a discrete event system using boolean loloic, language theory and finite state automata and to perform some basic operations (composition, determinization, determination of marked languages) allowing their behavior to be analyzed.

Prerequisites

Boolean logic

Assessment

Written (theoretical knowledge of language theory and finite state automata, skills in modeling SEDs using finite state automata)

Teaching program

- Reminders on 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 (synchronous product and 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).

Total hours : 30
Lecture hours : 7
Tutorials hours : 5
Practical/lab hours : 18

Objective

The objective of this EC is to acquire and consolidate the basics of Python programming, algorithms and computer machine architectures: numbering system and assembler, advanced Python programming, numerical calculation algorithms

Skills acquired

Design 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 6 practical exercises: The 5 tutorials: Tutorial 1: Numbering systems (integer, relative, real) Tutorial 2: Moving from high-level code to assembly code Tutorial 3: Introduction to object-oriented programming in Python Tutorial 4: Scientific programming in Python Tutorial 5: Algorithms in 2-dimensional arrays The 6 practical exercises: - Practical exercise 1: Programming a processor in assembly language - Practical exercise 2: Structured Python programming - Practical exercise 3 and Practical exercise 4: Scientific programming in Python - Practical exercise 5: Power of 4 project - Practical exercise 6: Synthesis

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), to bring weaker students up to speed, to meet (at least) the B1 level English quitus (see CECRL or CTI 2010 description) while aiming for B2. To develop professional skills.

Skills acquired

Professional skills and know-how. - Written and oral comprehension, written production in a foreign language.

Prerequisites

For all students: have followed instruction in this language, as LV1 or second foreign language, during their secondary studies, i.e. for a minimum of 5 years. Have at least level B1

Assessment

Continuous assessment: diagnostic, formative and summative assessments (grammar, vocabulary, oral/written comprehension, and written writing)

Teaching program

Students are offered activities aimed at perfecting the 4 language activities while not losing sight of final professional tasks such as writing a CV, a cover letter and a technical report in English. For the weakest students, the emphasis is also placed on consolidating grammatical and lexical bases. Action-oriented approach: the activities and materials used in class link skills to communicative tasks. The materials and methods are adapted according to the levels. - Oral comprehension: various authentic audio and video documents, websites - Written comprehension: letters, CVs, reports, press articles, excerpts from scientific articles. Activities for fixing and transferring the language structures studied. - Oral production: restitution, debates, exchanges, points of view using audio/video and written documents as sources. - Written production: writing CVs, cover letters, reports.

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

Objective

Students are divided into groups according to their skill level. Reach, strengthen, or exceed level B1 as described in the CEFR. Reinforcement of the basics, general language. Refresher in the 5 skills with a view to reaching level B1 at the end of S6, or going beyond for the most advanced students. For beginners: reach level A1 as described in the CEFR.

Skills acquired

Developing communication and exchange skills. Self-confidence in foreign languages. 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

Have followed the language studied in LV1, second foreign language or LV3 in secondary school. For beginners: commitment to follow the training in the chosen second foreign language throughout their schooling at ENSEM

Assessment

Continuous assessment (50%): regular tests during the semester; grades for participation in class. Written exam (50%).

Teaching program

General and everyday language, themes, supports and implementation as varied as possible. Themes: talking about oneself, studying, sports and leisure, health, work, business, living abroad, housing, daily life and traditions. In each lesson, work on the 5 skills (written and oral comprehension, oral interaction, written and oral expression). Systematic enrichment of active vocabulary (games, etc.). Use of online resources for intensive work on oral comprehension and language. Systematic training of oral comprehension through authentic audio and video documents. Training of written comprehension through press articles and other texts. Oral production: debates, exchanges, reports, role plays, presentations, pronunciation training, etc. Written production: written productions related to the points developed in the other skills, writing emails, taking a position, summarizing, etc.

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. Diagnostic assessment carried out by each student at the beginning of the year on the platform. Based on this assessment, a personalized course is established (independent work, the duration of which depends on the students' level). Review of rules and gradual eradication of errors by following the progression established by the platform. Continuous progress until the set objective is reached, or even beyond

Total hours : 20
Lecture hours : 14
Tutorials hours : 6
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

Prerequisites

None

Assessment

MCQ and case analysis

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 •tutorial 1: Characteristics of companies •tutorial 2: PESTEL analysis •tutorial 3: Strategies and development

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

MCQ

Teaching program

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

Total hours : 11
Lecture hours : 2
Tutorials hours : 9
Practical/lab hours : 0

Objective

The objective is to raise students' awareness of the issues of social and environmental responsibility in their future engineering missions, of living together with mutual respect and acceptance of differences, as well as the fight against sexist and sexual violence and all forms of discrimination. These themes are grouped under a triptych of equality - diversity - inclusion, and the objective of the course is to discover the different problems associated with them and the levers of action to prevent them.

Skills acquired

Understand the terminology "CSR" and its issues Understand the concept of diversity and inclusion and its implications Appreciate cultural diversity and respect for differences Identify discriminatory practices and non-inclusive behaviors Know the alert systems and know how to react

Prerequisites

No prerequisites However, the interesting prerequisites are in the order of personal qualities on open-mindedness

Assessment

Participation in the various sessions and workshops constitutes a mandatory discharge within the syllabus.

Teaching program

Introductory course on CSR issues in companies and within the missions of the engineer - Theater Forum to raise awareness of sexual and gender-based violence (VSS) by the Synergie troupe. The principle: a short scene dealing with sexism, cyberbullying and an assault in a student environment is played by the actors. The scene is then replayed, this time involving the students. The idea is to allow them to play the role of the main protagonist and to react to the insults of which she is the victim. This improvisational theater then leads to a collective reflection on the differences between sexist insult, sexual harassment and the notion of consent, often unknown to students. Reminder of the law. Conference on the prevention of risky behavior, particularly following the different forms of addiction. Student testimony on a sexist and sexual assault - Climate fresco to understand the issues and levers linked to climate change and its consequences

EC 5JEPLN61	Industrial conferences	*UE 5JUPLN06 General Training 1*	*P. Villette*

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

Objective

?

Skills acquired

?

Prerequisites

?

Assessment

Discharge validated on attendance at sessions

Teaching program

?

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

Objective

Support engineering students in developing their soft skills. Immerse yourself in and master different forms of written expression in a professional context.

Skills acquired

Develop self-awareness. Ability to organize ideas, knowledge, and/or information in order to write meeting minutes or practical work. Describe a scientific or technical subject. Master professional writing and presentation standards. Know how to present your work correctly. Write a CV, cover letter, and cover email. Interview techniques. Know how to reflect on your career plan.

Prerequisites

Satisfactory command of the French language.

Assessment

Oral assessment 50%, written assessment 50%

Teaching program

Tutorial 1 - Self-awareness and awareness of others (self-knowledge, relational effectiveness, etc.). Tutorial 2 - Verbal and non-verbal communication workshop. Tutorial 3 - Oral presentation in front of an audience. Tutorial 4 - Conducting and facilitating a meeting effectively. Tutorial 5 - Methodology for reporting on meetings. Tutorial 6 - Methodology for reporting on scientific work. Tutorial 7 - Written expression techniques. Tutorial 8 - How to convince.

EC 5JEPLN6.	Project management	UE 5JUPLN06 General Training 1	J.-C. Marpeau

Total hours : 18
Lecture hours : 2
Tutorials hours : 16
Practical/lab hours : 0

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

The assessment is based on the provision of a preliminary project report: presentation of the problem / analysis of needs (5 pts) - Identification of the objectives to be achieved and the risks (5 pts) - Structuring and management of the project (5 pts) and general impression of the report (5 pts)

Teaching program

lecture: 1 session lecture 1 session: - presentation of the content of the project management courses, the expectations of the annual 1A project and presentation of the project management guide for students - What is a project? - the complexity of a project (systemic vision) - The project approach (V process; agile methods, project portfolio management) tutorial: 8 sessions - Contextualization of a project and needs analysis - From needs to functions - Risks and opportunities - Converge towards a solution - Plan your project - monitoring your project - closing your project - Documentation, supports and tools

EC 5JEPLN6:	1st year project	UE 5JUPLN06 General Training 1	J.-C. Marpeau

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

Objective

Through a large-scale design engineering study, the aim is to gain an insight into the multiplicity of skills required to successfully complete an engineering project within the ENSEM engineer profile.

Skills acquired

Project management, ability to work collectively in a multidisciplinary project

Prerequisites

Scientific and technical skills at CPGE level, common sense, open-mindedness and an ability to work in a team and independently

Assessment

No evaluation at this stage of the project's progress

Teaching program

The subject posed by the teachers deals with a large-scale engineering problem, preferably multidisciplinary in nature and with a touch of innovation. It offers multiple study possibilities: scientific study (modeling, simulation), technical study (sensors, actuators, materials, dimensioning), cost study, etc. The student is required to study its overall feasibility and explore in detail some of its specific aspects. Some studies may lead to a technical realization but this is not the main objective. Industrial problems in conjunction with companies are also proposed, provided that the spirit of the project is respected and confidentiality aspects are resolved. The project groups work in complete autonomy (under the responsibility of a tutor who acts as a client). Regular monitoring of the project's progress is provided by the group through the provision of regular reports but also various documents: - Preliminary project report - Mid-term report - Final report

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Academic year 2025-2026
Detailed curriculum 2025-2026 NRJ_FISE

Semester S6

Code	Course Unit	ECTS	Code	Course	Coeff	Teacher	Vol	CM	TD	TP
			6JEPLN30	Probability and Statistics	0,4	*A. Gueudin*	**34**	18	16	0
			6JEPLN31	Optimization & Graph	0,3	*P. Riedinger*	**30**	16	14	0
6JUPLN03	Tools for mathematics 2	**5**	6JEPLN32	Numerical Analysis 2	0,3	*?*	**20**	8	6	6
			6JUPLN10	Mechanics for the engineer	0,5	*J.-F. Schmitt*	**30**	14	8	8
6JUPLN01	Applied Mechanics	**5**	6JUPLN11	Fluid mechanics and applications	0,5	*N. Rimbert*	**30**	12	10	8
			6JEPLN40	Electrical machines	0,5	*D. Netter*	**30**	13	8	9
6JUPLN04	Electricity 2	**5**	6JEPLN41	Power electronics	0,5	*L. Baghli*	**30**	13	8	9
			6JEPLN50	Automatic - Dynamics and Control of Systems	0,5	*J. Daafouz*	**30**	14	7	9
6JUPLN05	Information Sciences 2	**5**	6JEPLN51	Algorithmics and Object-Oriented Programming	0,5	*V. Chevrier*	**30**	7	5	18
			6JEPLN60	English	0,5	*C. Corringer*	**24**	0	24	0
			6JEPLN61	Modern Languages 2	0,5	*A. Quesada*	**24**	0	24	0
6JUPLN06	Languages 2	**5**	6JEPLN62	Validation of the French language clearance certificate	pass/fail	*A. Quesada*	**1**	0	1	0
			6JEPLN72	Management	0,2	*F. Temsamani*	**16**	10	6	0
			6JEPLN73	Innovation and Entrepreneurship	0,2	*F. Temsamani*	**12**	0	12	0
			6JEPLN70	Electrical authorization and occupational health	pass/fail	*T. Boileau*	**0,5**	0	0	0,5
			6JEPLN76	CSR 2	pass/fail	*C. Laurent*	**14**	8	6	0
			6JEPLN71	Industrial conferences	pass/fail	*P. Villette*	**6**	6	0	0
			6JEPLN74	Communication and professional integration	0,2	*A. Thimon*	**14**	2	12	0
6JUPLN07	General Training 2	**5**	6JEPLN75	1st year project	0,4	*J.-C. Marpeau*	**20**	0	0	20

EC 6JEPLN3(	Probability and Statistics	UE 6JUPLN03 Tools for mathematics 2	A. Gueudin

Total hours : 34
Lecture hours : 18
Tutorials hours : 16
Practical/lab hours : 0

Objective

The objective of this course: • Probabilities: manipulate random variables to model random phenomena (for example, model the lifetimes of systems that may experience failures at random times). • Statistics: calibrate models seen in probability, on real data. Test the relevance of such models on concrete, real cases.

Skills acquired

Probabilities & Statistics

Prerequisites

Integral calculus (simple and multiple, in particular change of variables, and Jacobian). Calculus of series

Assessment

Written exam

Teaching program

lecture 1 & tutorial 1: events, probabilities, random variables, mean, variance lecture 2 & TD2: distribution function, characteristic function, calculation of probability distribution, independence of several random variables. CM3 & TD3: random vectors. lecture 4 & TD4: law of large numbers, central limit theorem, confidence intervals. lecture 5: tests lecture 6 & TD5: tests and test power lecture 7 & TD6: graphical analysis and Chi2 test of sample normality. Estimation of model parameters (via maximum likelihood and the method of moments). lecture 8 & TD7: simple linear regression. lecture 9 & TD8: multiple linear regression.

Total hours : 30
Lecture hours : 16
Tutorials hours : 14
Practical/lab hours : 0

Objective

Optimization: The objective is to provide a basic culture in numerical optimization under constraints. Formulation and methods of numerical resolution of the main optimization problems of the engineer. Illustration of the operation of certain algorithms and programming (gradient, projected gradient and Uzawa) on machine. Graphs: Introduce graph theory and the main algorithms allowing to exploit them: search for paths (Eulerian, Hamiltonian, of minimum length), search for trees (spanning, of minimum weight), determination of flows (Ford-Fulkerson) and couplings.

Skills acquired

Optimization: Knowledge of the necessary minimum conditions under constraints and resolution on simple examples. Formulation and translation of an optimization problem. Know how to operate in the choice of a numerical method of resolution according to the nature of the problem and implementation. Graphs: Know how to model and solve simple problems of scheduling, assignment, routing

Prerequisites

Mathematics at the 1st cycle of scientific level or preparatory classes for the major scientific schools

Assessment

Optimization: Practical work: Ability to implement an optimization algorithm under constraints. Exam: Ability to solve a simple problem (linear or quadratic). Graphing: one-hour table exam

Teaching program

Optimization (8 lecture, 8 tutorial) Unconstrained optimization (Necessary and sufficient conditions of local minimum, Principle of descent methods and Convergence criterion, Algorithms: Gradient, Newton, Quasi-Newtonian (BFGS, DFP), Least squares: Gauss Newton and Levenberg Marquard, Conjugate gradients. Constrained optimization (Kuhn and Tucker conditions, Algorithms: linear programming, quadratic programming (Eliminations, active constraints), nonlinear programming (penalization method, SQP), convex problems (Projected gradient, Dual methods / Uzawa), Integer programming (Branch and Bound). Graph (8 lecture, 6 tutorial) Brief history Introduction Models for representing a graph Study of connectivity Eulerian and Hamiltonian paths Path finding methods Scheduling problems Trees and arborescences Networks, transport networks and flow problems Couplings – allocation problems

Total hours : 20
Lecture hours : 8
Tutorials hours : 6
Practical/lab hours : 6

Objective

Numerical Analysis is taught through two complementary ECs: Numerical Analysis 1 in semester 5 and Numerical Analysis 2 in semester 6. This course provides an introduction to the different techniques for numerically solving problems encountered in engineering sciences. Its objective is to provide the resolution techniques in numerical mathematics, the associated algorithms and their computer implementation (under Matlab) for the simulation of deterministic problems.

Skills acquired

Students are led, step by step, towards understanding numerical mathematics useful in their engineering training. Individual problem solving should lead students to demonstrate greater autonomy. In particular, at the end of this course, students should be able to analyze the problem posed, determine the most appropriate numerical method to solve the problem, implement this method and analyze the results obtained.

Prerequisites

good command of basic mathematical concepts (analysis, algebra, etc.) acquired during the first two years of higher education and within the framework of the "Mathematics for Engineers" module is required. Similarly, a mastery of computer tools, algorithms, and basic programming is assumed. Obviously, mastery of the concepts acquired during the EC Numerical Analysis 1 is required.

Assessment

Validate skills through digital practical work reports and a written test

Teaching program

Numerical resolution of linear systems; Numerical resolution of differential equations;

Total hours : 30
Lecture hours : 14
Tutorials hours : 8
Practical/lab hours : 8

Objective

The goal is to develop models for structural design. These models, developed using simplifying assumptions based primarily on geometry, represent 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 mechanics

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. 2-hour final exam.

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.) The statements of the problems addressed during each session are given a few days before the tutorial session. Students must prepare each session in writing (preparation time: 1h30 to 2h per session). Teachers check the preparatory work carried out during the session and can collect it. Practical work: practical work 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 6JUPLN1	Fluid mechanics and applications	UE 6JUPLN01 Applied Mechanics	N. Rimbert

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

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: - Calculate flow forces on an obstacle - Calculate 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

Final assessment lasting 120 minutes covers both parts of the course (calculation of force and pressure losses). One exercise per part. Authorized documents: None, (abacuses will be provided where applicable) non-communicating calculator required

Teaching program

Hydrostatics: Fundamental Equation, principle of fluid manometer, force on a dam, force on a submerged 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 lab work: calculation of pressure/force losses and introduction to Fluent software.

EC 6JEPLN4(	Electrical machines	UE 6JUPLN04 Electricity 2	D. Netter

Total hours : 30
Lecture hours : 13
Tutorials hours : 8
Practical/lab hours : 9

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Homework + Practical work notes.

Teaching program

Missing information

Total hours : 30
Lecture hours : 13
Tutorials hours : 8
Practical/lab hours : 9

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

Total hours : 30
Lecture hours : 14
Tutorials hours : 7
Practical/lab hours : 9

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

Total hours : 30
Lecture hours : 7
Tutorials hours : 5
Practical/lab hours : 18

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

EC 6JEPLN6(	English	UE 6JUPLN06 Languages 2	C. Corringer

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

Objective

The aim of this module is to consolidate the B1 level of the weakest students, and to reach B2+ /C1 for the strongest, to develop oral expression skills and to begin preparation for the TOEIC.

Skills acquired

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

Prerequisites

For all students: have received instruction in this language, as LV1 or second foreign language, during their secondary studies, i.e. for a minimum of 5 years. Have at least level B1.

Assessment

Continuous assessment: diagnostic, formative and summative assessments (vocabulary, oral/written comprehension type TOEIC, and continuous or interactive oral exams).

Teaching program

Continuation of oral skills development work in order to be able to: - express oneself on complex subjects in a clear and well-structured way, give an opinion on a problem, use language effectively and flexibly in academic, professional and social life, understand a specialized discussion in one's professional field, understand the content of concrete or abstract subjects - in a text, an audio and/or video program - using a "standard" language. - reproduce in broad outline any authentic written and oral document (e.g. press articles, English-language news channels, audio programs) relating to various areas: social, cultural and professional life. Introduction to the TOEIC test. Action-oriented approach: the activities and materials used in class link skills to communicative tasks and preparation for the TOEIC test. Materials and methods are adapted according to the levels.

EC 6JEPLN6.	**Modern Languages 2**	*UE 6JUPLN06 Languages 2*	*A. Quesada*

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

Objective

Students are divided into groups according to their skill level. Reach, strengthen, or exceed level B1 as described in the CEFR. Reinforcement of the basics, general language. Refresher in the 5 skills with a view to reaching level B1 at the end of S6, or going beyond for the most advanced students. For beginners: reach level A1 as described in the CEFR.

Skills acquired

Developing communication and exchange skills. Building self-confidence in foreign languages. Understanding written and spoken language, and producing written and oral texts (continuously and interactively) in a foreign language. Knowing how to set goals and learning how to learn.

Prerequisites

Have followed the language studied in LV1, second foreign language or LV3 in secondary school. For beginners: commitment to follow the training in the chosen second foreign language throughout their schooling at ENSEM

Assessment

Continuous assessment (50%): regular tests during the semester; grades for participation in class. Written exam (50%).

Teaching program

General and everyday language, themes, supports and implementation as varied as possible. Themes: talking about oneself, studying, sports and leisure, health, work, business, living abroad, housing, daily life and traditions. In each lesson, work on the 5 skills (written and oral comprehension, oral interaction, written and oral expression). Systematic enrichment of active vocabulary (games, etc.). Use of online resources for intensive work on oral comprehension and language. Systematic training of oral comprehension through authentic audio and video documents. Training of written comprehension through press articles and other texts. Oral production: debates, exchanges, reports, role plays, presentations, pronunciation training, etc. Written production: written productions related to the points developed in the other skills, writing emails, taking a position, summarizing, etc.

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. 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.

Total hours : 16
Lecture hours : 10
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. •Position yourself as a manager and solve a problem as a team.

Prerequisites

Basics of the business environment.

Assessment

Written assessment: 50% Oral assessment 50%

Teaching program

•lecture 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) • lecture 2 - The manager's missions: •The challenges of team cohesion •Development of leadership •Conditions for success • lecture 3 - The manager's functions: •Role and posture •Skills and soft skills •Establishment of a hierarchical position •Setting objectives •Mobilizing resources (delegating and empowering, planning talent development) • lecture 4 - Decisions and the decision-making process: •Types of decisions •Emotional intelligence •The decision-making model •Contingency factors • lecture 5 - Essential practices: •Intercultural management •Risk management •Conflict management •Conducting individual interviews

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

Objective

The objective of this EC in collaboration with Peel is to raise awareness among Ensem students over 2 days about entrepreneurial culture by allowing them to design a scenario related to entrepreneurship and to evaluate its coherence.

Skills acquired

Transforming an idea into a business opportunity Working on and mobilizing concepts concerning intellectual property, accounting and legal status, project marketing Public speaking

Prerequisites

The Peel IDéO© training tool used is aimed at the student public as a whole – no prerequisites required.

Assessment

Students will be assessed on their participation and work in the various workshops as well as on the quality of their final pitch.

Teaching program

After initial training, students are divided into project groups. Throughout the first three half-days, they will attend thematic workshops (IDéO© method, financial analysis, project marketing) and build an entrepreneurial scenario based on an innovative idea. During the last half-day, they will prepare the pitch for their project (5 minutes/project), which they will present to a jury and an audience who will elect the best pitch.

EC 6JEPLN7(	**Electrical authorization and occupational health**	***UE 6JUPLN07 General Training 2***	***T. Boileau***

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

Objective

The objective of this module is to validate the practical part of the accreditation 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. Know how to implement the theoretical skills acquired during the theoretical part of the electrical qualification 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 assessment for the "BE Essai" qualification, carrying out an electrical manipulation given by specifications

Total hours : 14
Lecture hours : 8
Tutorials hours : 6
Practical/lab hours : 0

Objective

Develop a citizen engineer posture, aware of the ethical, social and environmental implications of the technical projects to which he may be called upon to contribute - Recognize and explain the diversity of issues and positions and their sometimes divergent interests and experience the complexity of public debate and the difficulty of reaching a consensus

Skills acquired

Being able to step back from one's own judgment and listen to divergent positions, and understanding the diversity of issues surrounding the different missions of engineers

Prerequisites

None

Assessment

Discharge validated on attendance at sessions

Teaching program

lecture sequence: - CM1: environmental issues: current situation (planetary boundaries, systemic thinking, ecosystem services) - CM2: obligations in companies (what was done yesterday, what is being done today, what will have to be done tomorrow) - CM3: ethics and responsibility of the engineer - CM4: the art of debating and building consensus Sequence of three TDs: Reconstruction of a public debate around a major hospital infrastructure construction project: issues, difficulties and building consensus

EC 6JEPLN7.	**Industrial conferences**	*UE 6JUPLN07 General Training 2*	*P. Villette*

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

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Discharge validated on attendance at sessions

Teaching program

Missing information

Total hours : 14
Lecture hours : 2
Tutorials hours : 12
Practical/lab hours : 0

Objective

•Support the engineering student in building their personal and professional project. •Master internship and job search techniques. •Structure feedback in the form of an essay.

Skills acquired

•Master the tools related to internship search and professional integration. •Define and implement a job search or training strategy. •Define the strengths and weaknesses of an application and build an argument. •Master your e-reputation and its promotion on professional networks. •Prepare your professional interviews. •Contribute to the definition of a realistic and achievable professional project. •Structure a reasoning within the framework of an internship restitution.

Prerequisites

Good command of the French language.

Assessment

Written assessment 50%, oral assessment 50%

Teaching program

•lecture: Preparation of feedback and defense of the worker internship •tutorial 1: Oral techniques and structuring for the personal and professional project •tutorial 2: Preparation of tools for companies •tutorial 3: Organization of active prospecting •tutorial 4: Interview techniques •tutorial 5: Restitution methodology •tutorial 6: Preparation for the restitution of the worker internship

EC 6JEPLN7:	1st year project	UE 6JUPLN07 General Training 2	J.-C. Marpeau

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

Objective

Through a large-scale design engineering study, the aim is to gain an insight into the multiplicity of skills required to successfully complete an engineering project within the ENSEM engineer profile.

Skills acquired

Project management, ability to work collectively in a multidisciplinary project

Prerequisites

Scientific and technical skills at CPGE level, common sense, open-mindedness and an ability to work in a team and independently.

Assessment

Evaluation based on the provision of a mid-term report and a final project report (quality of the deliverable, compliance with the specifications, project management elements, quality and organization of bibliographic resources, etc.) Presentation of all work as part of a defense (defense, structuring of documents, motivation, etc.)

Teaching program

The subject posed by the teachers deals with a large-scale engineering problem, preferably multidisciplinary in nature and with a touch of innovation. It offers multiple study possibilities: scientific study (modeling, simulation), technical study (sensors, actuators, materials, dimensioning), cost study, etc. The student is required to study its overall feasibility and explore in detail some of its specific aspects. Some studies may lead to a technical realization but this is not the main objective. Industrial problems in conjunction with companies are also proposed, provided that the spirit of the project is respected and confidentiality aspects are resolved. The project groups work in complete autonomy (under the responsibility of a tutor who acts as a client). Regular monitoring of the project's progress is provided by the group through the provision of regular reports but also various documents: - Preliminary project report - Mid-term report - Final report

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Academic year 2025-2026
Detailed curriculum 2025-2026 NRJ_FISE

Semester S7

Code	Course Unit	ECTS	Code	Course	Coeff	Teacher	Vol	CM	TD	TP
			7JENRJ20	Distributions	0,334	*?*	**15**	9	6	0
			?	Introduction to AI	0,334	*?*	**15**	9	6	0
7JUNRJ02	Tools for the engineer	**4**	7JENRJ21	partial differential equations	0,334	*?*	**15**	9	6	0
			7JENRJ30	Electromechanical conversion of energy	0,334	*A. Labergue*	**24**	8	4	12
			7JENRJ31	Energy chain conversion design office	0,334	*M.Urbain*	**26**	6	0	20
7JUNRJ03	Energy conversion	**5**	7JENRJ32	Materials for energy	0,334	*G. Pernot*	**20**	8	12	0
			7JENRJ40	Introduction to heat transfers	0,5	*S. Didierjean*	**30**	8	12	10
7JUNRJ04	Mechanics	**5**	7JENRJ41	Mechanics of rotating machines	0,5	*M.Bordron*	**30**	16	10	4
			7JENRJ50	Power Electronics	0,5	*S. Pierfederici*	**30**	16	6	8
7JUNRJ05	Electrical Engineering	**5**	7JENRJ51	Electrical machines	0,5	*N. Takorabet*	**30**	10	8	12
			7JENRJ06	Signal processing	0,5	*D. Wolf*	**30**	18	8	4
7JUNRJ06	Information Sciences 3	**5**	7JENRJ61	Sensor networks	0,5	*?*	**30**	10	5	15
			7JENRJ14	CSR 3	pass/fail	*B. Remy*	**14**	10	4	0
			7JENRJ15	Industrial conferences	pass/fail	*P. Villette*	**6**	6	0	0
			7JENRJ10	Communication and professional integration	0,1429	*F. Temsamani*	**14**	6	8	0
			7JENRJ11	Accounting Management	0,2857	*J. Binet*	**18**	6	12	0
			7JENRJ12	English	0,2857	*C. Corringer*	**24**	0	24	0
7JUNRJ01	General training 3	**6**	7JENRJ13	Living Language 2	0,2857	*A. Quesada*	**24**	0	24	0

EC 7JENRJ2(	**Distributions**	*UE 7JUNRJ02 Tools for the engineer*	*?*

Total hours : 15
Lecture hours : 9
Tutorials hours : 6
Practical/lab hours : 0

Objective

The objective of this course is to first introduce the notion of distribution which generalizes that of function, and which finds numerous applications in various fields of engineering such as partial differential equations or signal processing. Once these basic definitions have been introduced, the various standard notions involved in functional calculus will be developed by extension for distributions: derivation, limit, convolution, resolution of differential equations with second-member distribution, Fourier transform. The tutorial exercises will allow mastery of these new notions and the associated calculation rules.

Skills acquired

Concept of distribution Calculation rules for distributions: derivation, limit, convolution, resolution of differential equations, Fourier transform

Prerequisites

Basics of function analysis; Fourier transform of functions; integral calculus

Assessment

Validate skills through a written test.

Teaching program

The course is structured according to the following chapters: • Distributions • Derivation and limit of distributions • Convolution of distributions and applications • Fourier transform of temperate distributions

EC ?	**Introduction to AI**	*UE 7JUNRJ02 Tools for the engineer*	*?*

Total hours : 15
Lecture hours : 9
Tutorials hours : 6
Practical/lab hours : 0

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

EC 7JENRJ2:	partial differential equations	UE 7JUNRJ02 Tools for the engineer	?

Total hours : 15
Lecture hours : 9
Tutorials hours : 6
Practical/lab hours : 0

Objective

The objective of this course is to provide the main elements that allow understanding the theory of partial differential equations (PDEs) as well as their numerical resolution. We will begin by introducing some PDE models involved in the field of engineering sciences. We will then discuss the notion of variational formulation of PDEs and the associated Lax-Milgram theory. A second part of the course will be oriented towards the numerical resolution of PDEs by finite elements, then by finite differences. The tutorial sessions will allow understanding the main concepts of the course and implementing numerical methods for PDEs.

Skills acquired

Basic elements of PDE theory Writing and properties of a weak formulation for a given boundary value problem Numerical resolution of PDEs

Prerequisites

Properties and calculation rules for functions – basic numerical analysis (Lagrange interpolation, numerical resolution of linear systems, numerical derivation, numerical integration) - Matlab

Assessment

Assessment by a written test

Teaching program

The program is as follows: • Introduction to PDE models • Weak formulation and Lax-Milgram theory • Numerical approximation of PDEs by finite elements • Numerical approximation of PDEs by finite differences

Total hours : 24
Lecture hours : 8
Tutorials hours : 4
Practical/lab hours : 12

Objective

This course is an introduction to the production of electricity from renewable energy, particularly using hydraulic (hydraulic turbines) and air (wind turbines). Although electrical machines are an essential element for the electromechanical conversion of energy, the focus is on the production of mechanical energy via a rotating wheel. The aim is to establish a comprehensive approach to identifying and modeling the energy flows and losses involved, thus making it possible to evaluate the machine's performance.

Skills acquired

- Knowledge of turbomachinery and wind turbine families and their operating characteristics - Design a hydraulic turbine and a wind turbine to produce mechanical energy - Model mechanical losses and evaluate the performance of a hydraulic turbine or a wind turbine

Prerequisites

Fluid Mechanics and Applications S6

Assessment

Exam to assess the level of knowledge in electromechanical energy conversion. Evaluation of practical skills acquired during practical sessions with a simulation.

Teaching program

lecture: 4 sessions of 2 hours during which the following points will be covered - General theory of rotating machines: classification, global balances, speed triangle, Euler's theorem, similarity and dimensionless analysis, - Turbopumps: classification, theoretical characteristics of centrifugal pumps, balance and efficiency - Hydraulic turbines: constitution, balance and efficiency, action and reaction turbines, turbine selection diagram - Wind turbines: origin and characterization of the wind, classification of wind turbines, constitution, theory and Betz limit tutorial: 2 sessions of 2 hours devoted to solving exercises and concrete problems to apply the concepts seen in class lab work: 3 sessions of 4 hours. Two sessions are devoted to the practical study of a generator (centrifugal pump) and a receiver (Pelton turbine or horizontal axis wind turbine) The last session consists of an assessment with a simulation in the lab work room.

Total hours : 26
Lecture hours : 6
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 S6Automatic S6

Assessment

The module assessment is based entirely on the project report.

Teaching program

Lecture hours :2h : dc current motor, transient dynamics modelling following a voltage step or a torque step disturbance, technology, composition4h : tree phase thyristors rectifier (principle, efficiency, energy quality), back-to-back diodes rectifier and buck switching power supplyPractical 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

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

Objective

In this module, an introduction to materials science will be presented through the three main sectors, relating to current issues of Energy and Renewable Energies, addressed at ENSEM: Materials for the mechanics of systems Materials for thermal in nano-systems and renewable energies Magnetic and semi-conductor materials.

Skills acquired

Know several classifications of materials Recognize the physical properties: mechanical, thermal and magnetic of the different classes of materials Know how to read a binary phase diagram Know how to size a magnet according to the specifications Understand the physical mechanisms influencing heat transfer Know how to choose a material according to the targeted energy applications: mechanical, magnetic or thermal

Prerequisites

Basic concepts in continuum mechanics (materials component for mechanics) Basic concepts in thermodynamics and heat transfers Basic concepts in magnetostatics

Assessment

The assessment will take the form of a 2-hour written exam covering the three parts covered in this course.

Teaching program

lecture 1 (Hat) Introduction to the major classes of materials: metals, semiconductors, ceramics and polymers as well as composite materials from these different classes. Several examples of exploitation and methods of control of physical properties: mechanical, thermal, magnetic and electrical associated with each class will be presented as a preliminary to the 3 specialized lecture sessions that follow, lecture 2: materials component for mechanics Introduction to the relationships "microstructure (atomic to microscopic scales) / mechanical properties" in the case of crystalline materials (metals and ceramics) and amorphous materials (polymers and glasses). lecture 3: materials component for thermal in nano-systems and renewable energies Introduction to the fundamental concepts of heat transfer at micro and nanoscopic scales. The notion of control and manipulation of thermal properties at small scales will be addressed and linked to applications in the promising field of renewable energies. lecture 4: Materials section for superconductivity and magnetic materials Introduction to the magnetic material medium and magnets, microscopic and macroscopic representation of magnetization, constitutive law and Evershed criterion. Introduction to superconductors. Tutorials: The tutorial sessions will allow you to deepen the knowledge seen in class through concrete examples: Learning to read phase diagrams of binary alloys. Implementation of magnetic sheet choices. Dimensioning and choice of magnets. Optimization of the properties of a Seebeck effect thermoelectric generator.

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

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

Report on practical work Final exam

Teaching program

Lectures (8h) 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 (12h) Methodology tutorials, i.e. getting to grips with the concepts and tools in thermal energy transfer by conduction and radiation. Study of cooling fins, Notion of thermal resistances, exchanges by radiation between opaque walls, radiative balance, etc. Practical work (10h) 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 to deduce thermal parameters.

Total hours : 30
Lecture hours : 16
Tutorials hours : 10
Practical/lab hours : 4

Objective

Become familiar with the equations of Euler-Lagrange dynamics. Apply these equations to dynamic systems, particularly rotating machines. Predict the behavior of these machines (motion, speed, resonance). Refine the models with phenomena specific to rotating machines.

Skills acquired

Modeling the dynamic behavior of a system, particularly a rotating machine. Modeling faults in rotating machines and identifying critical operating cases.

Prerequisites

Solid mechanics course continuum mechanics course

Assessment

Assessed practical work 2-hour final exam

Teaching program

lecture - Introduction to the Euler-Lagrange dynamics equations and solving the equations tutorial - Application of the Euler-Lagrange equations to simple dynamics cases lecture - Approach to the equations for rotating machines. Consideration of phenomena specific to rotating machines: static/dynamic unbalance, shaft bending, bearings, magnetic force (motor). tutorial - Application to a rotating machine. lab work - Numerical application on a rotating energy system. Numerical resolution of a complete problem. lab work - Physical application on a rotating machine. Measurement and analysis of vibrations.

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

Objective

The objective of this course is to enable students to acquire the basic concepts to understand the operating principles of the main power converters used in DC/DC conversion with and without galvanic isolation, AC/DC and DC/AC. Their instantaneous and average dynamic modeling, their control architecture and their sizing will be covered. The two tutorials will provide a detailed discussion of two conversion structures (isolated DC DC and three-phase DC AC) that are very common in industry.

Skills acquired

Acquisition of the knowledge elements required for the study of isolated DC/DC, DC/AC and AC/DC power electronic converters. Knowledge of their static and dynamic behavior as well as common control strategies.

Prerequisites

S6 power electronics, linear automatic

Assessment

Grade 1 = Practical work grade Grade 2 = Exam grade Final grade = 0.4*Grade 1 + 0.6*Grade 2

Teaching program

Lectures 2h- Reminder on the methodology for studying static converters: applications to usual non-isolated DC DC choppers 4h- Study of isolated DC/DC converters: operating analysis, instantaneous and average modeling, studied Flyback Forward Push-Pull converters 4h- Static and dynamic modeling of DC/DC choppers - control of choppers in continuous and discontinuous conduction mode 2h- Single-phase forced-commutated inverter/rectifier: operating principle, modulation strategies, static and dynamic modeling, sizing 4h- Three-phase forced-commutated inverter/rectifier: operating principle, modulation strategies, PLL, Concordia and Park transformation, dynamic modeling and control, loss evaluation (moving average method) Tutorials 1 tutorial Study and control of an isolated Flyback converter operating in self-oscillating mode 1 tutorial Study of a Forward converter with Clamping circuit 1 tutorial modeling and control of a controlled rectifier single-phase Practical work 1 practical work on isolated static converters (Flyback, Forward) 1 practical work on the implementation of a three-phase inverter

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

Objective

This module follows the 1st year Electrical Machines module, its objective is to study electrical machines in their environment. The phase of presentation of physical principles, model establishment and parameter identification being done in the 1st year, this module focuses on the implementation of electrical machines as motors and generators in different situations. Variable speed drive, electrical energy management of an alternator or operation as an asynchronous generator in a wind turbine are examples of situations studied. A strong emphasis will be placed on the use of machine models for the study of energy balances.

Skills acquired

Skills acquired following this module: 1-Use of external models of electrical machines to study their operation in steady state and establish converted power balances. 2- Implementation of electrical machines as motors and generators (synchronous machines connected to the distribution network, autonomous synchronous alternator, electrical drives of the variable speed asynchronous machine, asynchronous generator connected to the network)

Prerequisites

1st year electrical machines course Notions of electromagnetism Electrical and magnetic circuits

Assessment

Continuous assessment Practical work reports End-of-semester exam

Teaching program

Lectures Synchronous machine: Nonlinear models, stability study, Generator operation (stand-alone or connected to the network), Motor operation with converter or connected to the network. Permanent magnet synchronous machine (introduction). Asynchronous machine: Reminders on establishing the electrical model. Motor operation on the network, Speed variation, Generator operation (MADA). Tutorials (4 TDs of 2 hours): Synchronous machine 1: Generator operation or stand-alone motor Synchronous machine 2: Generator operation connected to the network Asynchronous machine 1: Motor operation (speed variation) Asynchronous machine 2: Generator operation connected to the network (MADA) Practical work (4 sessions of 3 hours). lab work 1: Synchronous machine: Identification of the model parameters (No-load tests, in DC). Load tests in stand-alone generator TP2: Synchronous machine connected to the network (Motor: Mordey curve). Generator (active and reactive power management) TP3: Asynchronous machine with variable speed drive (via a drive) TP4: Asynchronous machine in generator operation (autonomous or connected to the network)

EC 7JENRJ0(	Signal processing	UE 7JUNRJ06 Information Sciences 3	D. Wolf

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

Objective

Master classic signal processing tools for analyzing continuous and digital signals without noise and with noise.

Skills acquired

Computer spectral analysis Sampling Linear filtering of digital signals Characterization and analysis of random signals

Prerequisites

Functional analysis, concepts of distribution, concepts of signals, Fourier transform, probabilities

Assessment

2-hour exam, 2 tests, 1 practical work report

Teaching program

Continuous signals and Fourier analysis: Frequency representation of signals Convolution Convolution operators in physics Fourier transform of functions Fourier transform of tempered distributions Sampling and series Energy properties and Fourier transform Limits of Fourier analysis Digital signals and processing: Digital signals and digital convolution Z-transform Z-transmittance of digital filters Frequency analysis of digital filters Synthesis of filters in IIR form, synthesis of filters in FIR form Random signals: Reminders on random variables Description of random processes (probability density at order 1 and 2, moments) Spectral densities, correlation functions, time and frequency representations Definitions of signal-to-noise ratio, white noise

Total hours : 30
Lecture hours : 10
Tutorials hours : 5
Practical/lab hours : 15

Objective

Energy systems utilize highly connected sensors and equipment via geographically distributed computer networks across multiple sites. The protocols used by these networks enable data (e.g., from building or industrial facility instrumentation) to be routed to processing and management centers. The objective of this module is to introduce the fundamental concepts of communication networks, their protocols, and implementation techniques for building a sensor network to exchange and collect data.

Skills acquired

Understand how networks and communication protocols work - Implement a sensor network and develop a simple data collection application

Prerequisites

Algorithms and Programming 1A

Assessment

Know how to integrate a sensor network into a system to collect data and make technological choices for its implementation Assessment methods: continuous assessment (practical work notes), written exam

Teaching program

Course: - General principles of operation of networks and communication protocols: OSI model and TCP/IP model - CAN protocol - Internet of Things protocols: LoRa and LoRaWAN, IEEE 802.15.4 - Programming of communicating applications: Socket - Introduction to IoT applications and communication security Tutorials: - TD1: network trace analysis - TD2: IP addressing and CRC - TD3 and TD4: CAN communication bus - TD5: communication security Practical work: - TP1: Development of a data collection application (monitoring application) - TP2: MQTT protocols and IoT applications - TP3: Low-power communication: Zigbee protocol - TP4 and TP5: LoRa protocol and applications

EC 7JENRJ14	CSR 3	UE 7JUNRJ01 General training 3	B. Remy

Total hours : 14
Lecture hours : 10
Tutorials hours : 4
Practical/lab hours : 0

Objective

The objective is to raise awareness among students about the themes of Sustainable Development & Social Responsibility through a series of conferences.

Skills acquired

Acquire an awareness of: - Sustainable Development - Social Responsibility - Carbon Impact of human and industrial activities - Ethics

Prerequisites

No prerequisites

Assessment

Evaluation is conducted through participation in the Climate Fresco and a series of scientific and humanities conferences. Each conference is evaluated through a quiz of approximately ten questions on the topic addressed.

Teaching program

DDRS module content 1) The challenges of the energy transition / the Anthropocene (Conf. Debate) 2) Shift Project – Carbon Impact – Digital Sobriety 3) Sustainable Development – Solution (Sobriety, efficiency and acceptability) (ENEDIS) 4) IPCC / RTE Report – Energy Mix (RTE). The Energy Mix and the energy future. 5) Argue the advantages and disadvantages of fossil and/or nuclear energy consumption compared to renewable energy consumption 6) LCA (Resources) and Industrial Ecology 7) DDRS within the company + Standards (Advanced Training Council - Arcelor) - Round Table. 8) Planetary boundaries (Water cycles, phosphorus, ozone layer, nitrogen, etc.) 9) Evaluate the impact of energy policies on the economy 10) Ethics and acceptability (Philosophy) vs. energy insecurity + Climate Fresco

EC 7JENRJ15	**Industrial conferences**	*UE 7JUNRJ01 General training 3*	*P. Villette*

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

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Discharge validated on attendance at sessions

Teaching program

Missing information

Total hours : 14
Lecture hours : 6
Tutorials hours : 8
Practical/lab hours : 0

Objective

•Support the engineering student in discovering the engineering profession. •Build the personal and professional project.

Skills acquired

•Prepare an oral presentation. •Discover several engineering professions. •Visit several companies. •Conduct professional interviews. •Identify your experience. •Develop a digital portfolio of experiences and skills.

Prerequisites

Master the skills of S5 and S6.

Assessment

Dissertation 40% Defense 40% Interview summary note 20%

Teaching program

•lecture 1: Meeting organized around a production engineer •lecture 2: Meeting organized around an R&D engineer •lecture 3: Meeting organized around a business engineer •tutorial 1: Preparation for the restitution defense •tutorial 2: Discovery of tools for developing the personal project •tutorial 3: Conducting an individual interview with a professional •tutorial 4: Promoting your experiences and skills

Total hours : 18
Lecture hours : 6
Tutorials hours : 12
Practical/lab hours : 0

Objective

Understand the concepts, principles of implementation and the content of summary documents for business management Understand the financial mechanisms of business operation Be aware of the financial consequences of business management decisions

Skills acquired

Be aware of the financial aspects of managing a business Understand the financial consequences of decisions to manage a business Restructure and reorganize financial statements to understand in a simplified way the financial aspects of managing a business (or a work team). Understand how to understand and interpret the financial statements of a company, see how to correct a situation that requires attention The complete management simulation with the practical application of concepts

Prerequisites

None

Assessment

continuous assessment

Teaching program

Presentation of the summary documents, content and understanding of the content of each of the documents and link with the company and its strategy Process of constructing the documents Functional approach to the balance sheet Breakdown of the income statement through the intermediate management balances Synthetic approach to the profitability of a company through the differential income statement tutorial: practical application of each tool, with interpretation

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) IELTS and DET are certifications requested by partner universities for double degrees abroad.

Skills acquired

Skills as defined by the CEFR at level B2 or C1.

Prerequisites

Have consolidated your B1 level. Have completed the S6 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 orals) + 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

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

Objective

For beginners: skills as described by the CEFR at level A2 or B1. For non-beginners: skills as described by the CEFR for level B1, B2, or C1 depending on the level group. Professional skills and know-how. Training for external certifications (students can take a certification if they wish). Development of professional skills, including through modules with a scientific and cultural focus. Discovery or deepening of specialist vocabulary and the language of engineering

Skills acquired

Developing communication and exchange skills. Building self-confidence in foreign languages. Understanding written and spoken language, and producing written and oral texts (continuously and interactively) in a foreign language. Knowing how to set goals and learning how to learn.

Prerequisites

For non-beginners: have a B1 level. For beginners, have an A2 level.

Assessment

Continuous assessment (50%): regular tests during the semester; grades for participation in class. Written exam (50%).

Teaching program

In each course, work on the 5 skills (written and oral comprehension, oral interaction, written and oral expression). Use of online resources for intensive work on oral comprehension and oral expression. Work on the language and development of professional skills through modules with a cultural and scientific focus. Systematic training of oral comprehension through authentic audio and video documents. Training of written comprehension through press articles and other texts. Oral production: debates, exchanges, reports, role plays, presentations, pronunciation training, etc. Written production: written productions related to the points developed in the other skills, writing emails, taking a position, summaries, etc. Module with a scientific focus: work on themes and documents related to the field of engineering. The engineering profession, preparation for writing summaries, reports, training for debates, simulated meetings, study of documents related to the key fields of engineering; know 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. Cultural module: work on significant cultural events or trends. Emphasis will be placed on the diversity of the media used. Students will be required to work in groups and on projects. External speakers related to the themes covered may speak during class (e.g.: international exchange students at ENSEM, members of associations, etc.) Themes: traditions, interculturality, the world of the arts, cinema, history, etc. Flexible according to the interests of each group.

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LORRAINE INP Ensem

Academic year 2025-2026
Detailed curriculum 2025-2026 NRJ_FISE

Semester S8

Code	Course Unit	ECTS	Code	Course	Coeff	Teacher	Vol	CM	TD	TP
			8JENRJ10	English	0,25	*C. Corringer*	**24**	0	24	0
			8JENRJ11	Modern Languages 2	0,25	*A. Quesada*	**24**	0	24	0
			8JENRJ13	CSR	0,25	*F. Temsamani*	**14**	8	6	0
			8JENRJ14	Industrial Conferences - Research Day	pass/fail	*B. Remy*	**12**	12	0	0
8JUNRJ01	General Training 4	**6**	8JENRJ12	Marketing Strategy & Business Simulation	0,25	*J.-C. Marpeau*	**21**	3	18	0
			8JENRJ20	Electrical Network Modeling	0,2	*S. Dufour*	**16**	8	4	4
			8JENRJ21	Integration of renewable energies	0,2	*J.-P. Martin*	**16**	10	2	4
			8JENRJ22	Characteristics of energy sources and storage elements	0,2	*A. Labergue*	**18**	18	0	0
			8JENRJ23	Heat networks	0,2	*B. Remy*	**14**	6	4	4
8JUNRJ02	8-01 General Knowledge of Networks, Sources and Storage Elements	**6**	8JENRJ24	Case study	0,2	*M.Urbain*	**16**	0	0	16
			8JENRJ30	Modeling and control of electrical machines	0,5	*F. Meibody*	**40**	20	12	8
8JUNRJ03	8-02 Dynamic Modeling and Electrical Machine Drives	**6**	8JENRJ31	Electrical machines connected to the network - failures and trai	0,5	*N. Takorabet*	**40**	16	8	16
			8JENRJ40	Current and emerging power supply structures	0,5	*S. Pierfederici*	**40**	20	8	12
8JUNRJ04	8-03 Advanced Power Electronics for Sationary and Embedded applications	**6**	8JENRJ41	Digital integration	0,5	*J.-P. Martin*	**40**	8	0	32
			8JENRJ80	Thermodynamics of energy systems	0,5	*S. Didierjean*	**40**	10	20	10
			8JENRJ81	Heat and mass transfer	0,375	*A. Labergue*	**30**	10	8	12
8JUNRJ08	8-04 Energy Transfer and Conversion	**6**	8JENRJ82	Fluid energy conversion	0,125	*O. Caballina*	**10**	6	4	0
			8JENRJ50	Turbulence	0,25	*O. Caballina*	**20**	12	8	0
			8JENRJ51	Aerodynamic	0,25	*A. Pereira*	**20**	12	8	0
			8JENRJ52	Fluid-structure interactions	0,25	*N. Louvet*	**20**	12	8	0
8JUNRJ05	8-05 Fluid Mechanics for the Engineer	**6**	8JENRJ53	Case study	0,25	*N. Louvet*	**20**	2	0	18
			8JENRJ60	Computer Aided Design	0,25	*M.Bordron*	**30**	0	0	30
			8JENRJ61	Life cycle analysis	0,25	*M. Bordron*	**10**	6	4	0
			8JENRJ62	Manufacturing technologies and processes	0,25	*M. Bordron*	**20**	10	2	8
8JUNRJ06	8-06 Design and dimensioning of solids and structures	**6**	8JENRJ63	Sizing case studies	0,25	*J.-F. Schmitt*	**20**	2	0	18
			8JENRJ72	Cryptography, Cybersecurity of industrial systems	0,25	*? / J. Daafouz*	**20**	8	4	8
			8JENRJ73	Distributed Systems, Web Services and Blockchain	0,25	*V. Chevrier*	**20**	8	0	12
			8JENRJ70	Analysis and evaluation of discrete event systems performance	0,25	*J.-F. Pétin*	**20**	8	4	8
8JUNRJ07	8-07 Safety and Cybersecurity	**6**	8JENRJ71	Operational Safety	0,25	*N. Brinzei*	**20**	10	4	6
			8JENRJ90	Signal processing and data transmission	0,375	*V. Louis-Dorr*	**30**	16	6	8
			8JENRJ91	Databases	0,375	*YQ Song*	**30**	10	8	12
8JUNRJ09	8-08 Signals, Data and the IoT	**6**	8JENRJ92	Implementing an Internet of Things application	0,25	*?*	**20**	2	0	18
			8JENR101	Numerical control	0,25	*J. Daafouz*	**20**	10	4	6
			8JENR102	Stability and stabilization of systems	0,25	*R. Postoyan*	**18**	10	4	4
			8JENR103	Digital integration with microcontrollers	0,25	*?*	**20**	8	0	12
8JUNRJ10	8-09 Stability, Control and Digital Integration	**6**	8JENR104	Smart grid application	0,25	*J. Daafouz*	**20**	4	4	12
			8JENR110	Introduction to Pattern Recognition	0,25	*S. Le Cam*	**24**	12	12	0
			8JENR111	Kernel methods - Support vector machines	0,25	*M.Kallas-Edelson*	**12**	6	6	0
			8JENR112	Neural networks	0,25	*M.Kallas-Edelson*	**12**	6	6	0
8JUNRJ11	8-10 Artificial Intelligence, Data Analysis and Machine Learning	**6**	8JENR113	Design office	0,25	*S. Le Cam*	**32**	0	0	32
			8JENR120	Analytical and digital BF electromagnetism	0,5	*J. Fontchastagner*	**40**	16	8	16
8JUNRJ12	8-11 Numerical Modeling and Simulation in Electrical Engineering	**6**	8JENR121	Simulations of electromagnetic devices	0,5	*C.-H. Bonnard*	**40**	4	0	36
			8JENR130	Introduction to numerical simulation in Mechanics & Thermal E	0,3334	*B. Remy*	**28**	8	0	20
			8JENR131	Digital CAD Tools - Fluid Mechanics - Thermal	0,3334	*N. Rimbert*	**26**	6	0	20
8JUNRJ13	8-12 Numerical Modeling and Simulation in Thermal, Fluid and Solid Mechanic	**6**	8JENR132	Finite element analysis of machines & structures	0,3334	*C. Laurent*	**26**	6	0	20
			8JENR140	H2 electrochemical systems	0,5	*G. Sdanghi*	**42**	42	0	0
8JUNRJ14	8-H2 Hydrogen Track: From Production to Energy Applications	**6**	8JENR141	Practical work & Case study	0,5	*M.Hinaje*	**38**	0	0	38
			8JE47N27	Fundamentals of Nuclear Energy (FST)	0,25	*X. Caron*	**20**	20	0	0
			8JE47N28	Upstream and downstream nuclear fuel cycle (FST)	0,25	*JS Kroll-Rabotin*	**18**	18	0	0
8JUNRJ15	8-Nuclear-1 Nuclear Training – Core Curriculum	**6**	8JENR150	Digital Methods & Tools	0,5	*N. Rimbert*	**42**	6	0	36
			8JENR160	Thermo-Hydraulics	0,25	*A. Labergue*	**20**	10	4	6
			8JENR161	Turbulence (nuclear formation)	0,25	*O. Caballina*	**20**	12	8	0
			8JENR162	Heat networks & thermodynamic systems	0,25	*B. Remy*	**20**	6	6	8
8JUNRJ16	8-Nuclear-2 Nuclear Training - Mechanics & Energy	**6**	8JENR163	Multiphysical behavior of materials, stress corrosion cracking	0,25	*JF. Ganghoffer*	**20**	16	4	0
			8JENR170	Transient regimes of synchronous alternators	0,25	*N. Takorabet*	**20**	8	4	8
			8JENR171	Modeling of electrical networks	0,25	*S. Dufour*	**20**	8	4	8
8JUNRJ17	8-Nuclear-3 Nuclear Training - Electrical Engineering	**6**	8JENR172	Modeling and control of electrical machines	0,5	*F. Meibody-Tabar*	**40**	20	12	8
			8JENR180	Cryptography, Cybersecurity of industrial systems	0,25	*?*	**20**	8	4	8
			8JENR181	Operational safety (nuclear training)	0,25	*N. Brinzei*	**20**	10	4	6
			8JENR182	Numerical control (nuclear training)	0,25	*J. Daafouz*	**20**	8	4	8
8JUNRJ18	8-Nuclear-4 Nuclear Training - Information Sciences	**6**	8JENR183	Stability and stabilization of systems (nuclear training)	0,25	*R. Postoyan*	**20**	12	4	4
	Projects (foreign students)	**25**		Projects (foreign students)	1	*S. Gallaire*				

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

Objective

Semester focused on oral English. The goal 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, 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)

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

Objective

For beginners: skills as described by the CEFR at level A2 or B1. For non-beginners: skills as described by the CEFR for level B1, B2, or C1 depending on the level group. Professional skills and know-how. Training for external certifications (students can take a certification if they wish). Development of professional skills, including through modules with a scientific and cultural focus. Discovery or deepening of specialist vocabulary and the language of engineering

Skills acquired

Developing communication and exchange skills. Building self-confidence in foreign languages. Understanding written and spoken language, and producing written and oral texts (continuously and interactively) in a foreign language. Knowing how to set goals and learning how to learn.

Prerequisites

For non-beginners: have a B1 level. For beginners, have an A2 level.

Assessment

Continuous assessment (50%): regular tests during the semester; grades for participation in class. Written exam (50%).

Teaching program

In each course, work on the 5 skills (written and oral comprehension, oral interaction, written and oral expression). Use of online resources for intensive work on oral comprehension and oral expression. Work on the language and development of professional skills through modules with a cultural and scientific focus. Systematic training of oral comprehension through authentic audio and video documents. Training of written comprehension through press articles and other texts. Oral production: debates, exchanges, reports, role plays, presentations, pronunciation training, etc. Written production: written productions related to the points developed in the other skills, writing emails, taking a position, summaries, etc. Module with a scientific focus: work on themes and documents related to the field of engineering. The engineering profession, preparation for writing summaries, reports, training for debates, simulated meetings, study of documents related to the key fields of engineering; know 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. Cultural module: work on significant cultural events or trends. Emphasis will be placed on the diversity of the media used. Students will be required to work in groups and on projects. External speakers related to the themes covered may speak during class (e.g.: international exchange students at ENSEM, members of associations, etc.) Themes: traditions, interculturality, the world of the arts, cinema, history, etc. Flexible according to the interests of each group.

EC 8JENRJ13	CSR	UE 8JUNRJ01 General Training 4	F. Temsamani

Total hours : 14
Lecture hours : 8
Tutorials hours : 6
Practical/lab hours : 0

Objective

Understanding and supporting ecological and digital transitions in businesses. Integrating legal, strategic, and operational aspects.

Skills acquired

Understand the legal frameworks (environment, labor, digital) and their impact on the company Master the strategies, tools and standards of sustainability, circular economy Carry out a strategic audit of transitions

Prerequisites

Course 1A of CSR

Assessment

50% investment and 50% return

Teaching program

lecture 1 – Regulatory framework for transitions. lecture 2 – Sustainable development management. lecture 3 – Digital transition management. lecture 4 – Transformation audit. tutorial 1 – Analysis of sustainable technologies. tutorial 2 – Critical analysis of a digital technology. tutorial 3 – Audit of the ecological and/or digital transformation of an organization.

EC 8JENRJ14	Industrial Conferences - Research Day	UE 8JUNRJ01 General Training 4	B. Remy

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

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

Total hours : 21
Lecture hours : 3
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

Course 1A in business knowledge, strategy and project management

Assessment

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

Teaching program

lecture: - Basics of accounting and financial analysis - Business strategy 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 relationships 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 the competition, from imperfect information and in necessarily limited time.

Total hours : 16
Lecture hours : 8
Tutorials hours : 4
Practical/lab hours : 4

Objective

This course is an introduction to high-voltage electrical networks, distribution, and transmission. It provides basic knowledge of network equipment, network management, power distribution, and short-circuit current calculations. The objectives are to understand the modeling of steady-state power lines and network transformers, to understand the different components of an electrical substation, to be able to use power distribution and short-circuit calculation software, and to have an idea of how it works.

Skills acquired

Knowledge of network components (lines, cables, transformers, substations) and their modeling. Mastery of the power distribution issue. Notions of voltage/frequency adjustments. Methodology for calculating short-circuit currents.

Prerequisites

S5 – General Electrotechnics, S5 – Tools for Electronics and Electricity, S6 – Numerical Analysis 2

Assessment

Written test

Teaching program

CM1 (2h) – HV power lines (overhead-underground). Structure, Equivalent electrical model. CM2 (2h) – Transformers (on-load tap changers, phase shifters, three-winding) – Electrical substations (typical structure, equipment) – Voltage/frequency settings. TD1 (2h) – Power lines: use of the Pi model CM3 (2h) – Power distribution. Introduction to the problem. Resolution methods. Test cases. Sensitivity analysis. Contingency analysis. TP1 (4h) – Power distribution. Introduction to power distribution software on a test case. Example of a study on a larger network. CM4 (2h) – Short-circuit currents. Three-phase and asymmetrical short circuits. Presentation of the calculation methodology. Basics of the IEC 60909 standard. TD2 (2h) – Calculation of short-circuit currents on a simplified network.

Total hours : 16
Lecture hours : 10
Tutorials hours : 2
Practical/lab hours : 4

Objective

The objective of this module is to introduce the electrical models of photovoltaic panels and different wind generators (synchronous and asynchronous generation), the specific power electronics architectures implemented to transfer energy from renewable sources (RE) to distribution networks as well as the associated control laws, while considering the specific constraints of the electrical network.

Skills acquired

Know how to model, size and implement a complete conversion chain allowing the integration of renewable energies of the photovoltaic and wind type into an electrical network, while taking into account network constraints.

Prerequisites

General Electrotechnics S5, Tools for Electricity and Electronics S5, Electrical Machines S6, Power Electronics S6, Automatics – Dynamics and Control of Systems S6, Electromechanical Conversion of Energy S7, Power Electronics S7, Electrical Machines S7.

Assessment

Case study on the injection of photovoltaic and wind energy into an electrical network (2 project reports).

Teaching program

The different points covered are (lecture 10h): - Solar panel models and implementation The different usual electrical models of photovoltaic cells are presented. Lambert's W function for modeling solar panels is introduced for simulation under homogeneous and heterogeneous operating conditions. The usual maximum power point search (MPPT) algorithms are presented (Perturbation & Observation, incremental conductance) and implemented on static converters. - Injection of photovoltaic and wind energy into the electrical network An introduction to the injection of photovoltaic and wind energy into an electrical network is presented. The specific architectures of the conversion chain with the usual control laws and their sizing are introduced and implemented for the injection of energy into a single-phase and three-phase network. The constraints relating to network frequency and voltage variations will be presented and implemented in the control of the conversion chain during a tutorial (2h) via the standard P(f) and Q(U) laws. A complete wind chain taking into account the electrical generator, the static converters, the control laws and the electrical network will be developed in simulation by the students. (lab work 4h).

Total hours : 18
Lecture hours : 18
Tutorials hours : 0
Practical/lab hours : 0

Objective

The growing number of renewable energy sources connected to electricity grids poses a real technical challenge. Indeed, due to the intermittent nature of renewable energies, networks can be subject to significant drops in voltage or electrical frequency. Thus, the integration of large storage capacities is a solution to strengthen the stability of networks. This course will present and characterize the main energy storage processes capable of storing large quantities of electrical energy: gravity storage, compressed air, flywheels, electrochemical accumulators (batteries), and supercapacitors.

Skills acquired

Know how to select and size an appropriate energy storage technology according to specifications (energy to be stored, power to be supplied, charge/discharge time or response time, etc.)

Prerequisites

Thermodynamics S5 Fluid mechanics and applications S6 Electromechanical conversion of energy S7

Assessment

Exam to assess the level of knowledge acquired on mechanical energy storage techniques and by electrochemical accumulators or supercapacitors

Teaching program

lecture: 9 sessions of 2 hours during which the following points will be covered - 6 hours devoted to energy storage processes based on mechanical concepts: * Gravity storage * Compressed air storage * Flywheel storage - 8 hours on electrochemical accumulators and supercapacitors * Vocabulary and technology: nominal characteristic quantities of a cell (voltage, capacity (Ah), energy), Ragone diagram, influence of temperature and current on discharge performance, distinction between installed energy and accessible energy, analysis of technical data sheets and sizing of a storage device, constraints of implementation of supercapacitors * Theoretical considerations and modeling: electrochemical kinetics and Randles diagram, equivalent electrical model seen from the external terminals, implementation and parameterization on Matlab / Simulink. - 4 hours given by an industrialist on redox flow battery

Total hours : 14
Lecture hours : 6
Tutorials hours : 4
Practical/lab hours : 4

Objective

Know how to model and size a heat network by integrating components and utilities.

Skills acquired

Know how to model and size a heat network by integrating components and utilities.

Prerequisites

Course in Thermodynamics S5 and Thermal Science S7.

Assessment

Implementation in the form of a practical exercise of pinch analysis in a simple academic case.

Teaching program

Evaluate the potential of a heat network based on the inventory of hot and cold sources (Pinch analysis). Input of a hot and/or cold source to ensure its operation. - Define the characteristics of the utilities to be integrated into the network to meet predefined specifications (heat network at the level of an industrial site, a city, a neighborhood or collective housing): production of hot water, steam, electricity and heating. - Optimize the efficiency of the network by choosing components and their control by integrating the load into the model. - Implementation and integration of models under Matlab Simulink (Simscape) Keywords/content: integration of conversion, storage and production components in a heat network by static and dynamic approaches.

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

Objective

This project is multidisciplinary, the objective is to implement the knowledge acquired during the different modules constituting the "energy networks" block and to apply them to a concrete research and development problem in engineering.

Skills acquired

Deepening and implementing the knowledge and tools presented in the areas covered in the "energy networks" block. Developing one's skills of initiative, synthesis and personal reflection with regard to concrete research and development problems in engineering.

Prerequisites

Lessons from the ECs of the “energy networks” block.

Assessment

Practical work report.

Teaching program

The topic is proposed by a teacher or a team of teachers from the training and the students will work individually or in groups depending on the subject and the work required to meet the specifications of the study. The project involves scientific, technical and technological considerations. It can simultaneously address different fields (electricity, thermal, mechanical, renewable energy, storage, etc.). The theoretical study may possibly be supplemented by experimental tests on a model to validate the idea in principle. The students will thus develop their skills of initiative, synthesis and personal reflection. The teacher who proposed the study topic will accompany the student in these research and analysis processes. In addition to these supervised hours intended to guide and advise the student as they progress in the resolution, additional and regular personal work will be necessary to complete the study.

Total hours : 40
Lecture hours : 20
Tutorials hours : 12
Practical/lab hours : 8

Objective

The objective of this course is the modeling and implementation of variable speed electric drives. It involves presenting and justifying the tools and transformations necessary for the dynamic modeling of electrical machines. Establishing dynamic models for the simulation and control of synchronous and asynchronous electrical machines powered via voltage inverters. Studying different strategies for controlling the torque of synchronous and asynchronous electrical machines. The applications in tutorial and lab work are the implementation of variable speed electric drives for synchronous and asynchronous machines.

Skills acquired

Know how to model and study the behavior of synchronous and asynchronous machines powered via voltage inverters. Implement torque and speed control of these machines, integrated into electromechanical energy conversion chains.

Prerequisites

- Electrical machines in S6 and S7 - Power electronics in S6 and S7

Assessment

The assessment is based on the average of the theoretical exam grade and the average of the practical part (tutorials and practical work). The practical grade is the average of the grades of the reports on the work carried out during the tutorials and practical work sessions. Final grade = [(Theoretical exam grade) + (Average grade of the tutorials and practical work)] * 0.5

Teaching program

Course (20h): ** Transformations and modeling tools for three-phase systems. ** Dynamic modeling of different types of synchronous and asynchronous machines with sinusoidal FMM, powered via PWM-controlled voltage inverters, for the simulation and control of electromechanical energy conversion chains. ** Torque control of synchronous and asynchronous machines powered by voltage inverters. ** Torque control strategies for synchronous machines, autopilot conditions. ** Principle of torque control of asynchronous machines by orienting the rotor flux or the stator flux along the direct axis (vector control of synchronous and asynchronous machines). Tutorials (3*4h in the computer room) ** TD1 (2*4h): Modeling in MATLAB/SIMULINK of a permanent magnet synchronous machine powered by a PWM-controlled voltage inverter; simulation study of its torque and speed control. ** TD2 (4h): Modeling under MATLAB/SIMULINK of a squirrel cage asynchronous machine powered by a PWM-controlled voltage inverter; study by numerical simulation of the torque and speed control of the machine considered by orienting the rotor flux along the direct axis. Practical work (2*4h in the Vehicle of the Future Room) ** TP1 (4h): Implementation of torque and speed control of a permanent magnet synchronous machine powered by a PWM-controlled voltage inverter. ** TP2 (4h): Implementation of torque and speed control of a squirrel cage asynchronous machine powered by a PWM-controlled voltage inverter.

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

Objective

This module aims to consolidate the basic knowledge acquired on three-phase electrical machines studied in S6 and S7, allowing them to be modeled in a more detailed manner and in unusual or degraded operations. The focus will be on transient and unbalanced regimes of synchronous and asynchronous machines.

Skills acquired

Study and implement machines using advanced saturation models (Potier) - Characterize the operation of synchronous machines in transient conditions - Implement experimental procedures for identifying machine parameters in transient conditions - Model and characterize transient and unbalanced conditions of asynchronous machines - Implement experimental procedures for characterizing and highlighting phenomena

Prerequisites

Common core electricity courses: - Electrical and electronic circuits, general electrical engineering - Electrical machines

Assessment

Practical work scenario to identify and characterize the behavior of electrical machines. Exam to assess the level of knowledge acquired on electrical machines in transient or unbalanced operation.

Teaching program

Part 1: Synchronous Machine: lecture (8h) Potter's Model - Transient regimes of synchronous machines - Special synchronous machines (variable reluctance) tutorial (4h): Potter's Model - Implementation of the numerical model of a synchronous machine in transient regime lab work (8h): Characterization tests in saturated and transient regime of a wound rotor synchronous machine Part 2: Asynchronous Machine lecture (8h) Modeling of the wound rotor asynchronous motor - unbalanced regime models - modeling in transient regime - modeling of the single-phase asynchronous machine tutorial (4h): Modeling in steady then unbalanced regime of an asynchronous machine, then rebalancing of the machine - modeling of the asynchronous machine in transient regime lab work (8h): Characterization tests in transient and unbalanced regime of an asynchronous machine; Parametric identification by different tests, comparison. Machine operation in degraded mode: performance evaluation

Total hours : 40
Lecture hours : 20
Tutorials hours : 8
Practical/lab hours : 12

Objective

Modern conversion structures present in aeronautical, railway, naval applications and emerging electrical networks make it possible to achieve, among other things, contactless energy transfer, ironless transformers, high power applications, the implementation of high power low voltage elements.

Skills acquired

The objective of this EC is to enable students to master methodological tools and establish dynamic models for the sizing, simulation and control of advanced static converter structures.

Prerequisites

S6 and S7 power electronics, linear automatic

Assessment

Practical work grade = (practical work report 1 + practical work report 2 + practical work report 3) / 3; Exam grade = 0.7 * Part 1 exam grade + 0.3 * Part 2 exam grade Final grade = 0.4 * (practical work grades) + (exam grade) / 0.6

Teaching program

Part 1: - Quasi-resonant and resonant choppers / resonant inverters (8h lecture / 4h tutorial) Keywords: Soft switching, contactless energy transfer, high-frequency structures with high power density. - Advanced DC/DC converter structures suitable for high-power low-voltage sources (6h lecture / 2h tutorial) Keywords: quadratic converters, voltage multiplier, interleaved converters, impedant inverters. Part 2: - multi-level - modulation strategies. (6h lecture / 2h tutorial) Keywords: multi-level inverters, vector PWM. Practical work TP1 (4h): Implementation of a low-voltage, high-current conversion structure on the “Energy” platform TP2 (4h): Implementation of a resonant converter for contactless energy transfer TP3 (4h): Implementation of an HVDC network using a multi-level inverter on the “Vehicle of the Future” platform

Total hours : 40
Lecture hours : 8
Tutorials hours : 0
Practical/lab hours : 32

Objective

Electrical systems are typically built around static converters whose control is used to control power flows. Control laws are increasingly being integrated into digital electronic components and embedded computer systems.

Skills acquired

Acquire the knowledge necessary to integrate the control laws of electrical systems into configurable and/or programmed digital circuits.

Prerequisites

Algorithms and Programming S5, discrete event systems Modeling S5, Algorithms and Programming S5, General Electrical Engineering S5, Tools for Electricity and Electronics S5, Power Electronics S6, Algorithms and Object-Oriented Programming S6, Power Electronics S7.

Assessment

Continuous monitoring during practical sessions and evaluation of reports associated with the two projects on the implementation of a control law on a DSC and on an FPGA.

Teaching program

The module is divided into two main parts: - Programmed digital circuits (4h lecture (2x2 h)) The elements covered will be: taking into account real-time constraints, synchronization, interrupts, timers, inputs/outputs, analog-to-digital conversion, pulse width modulation, introduction to the C language for DSC, programmed digital circuit structures, microcontrollers, DSPs, ... Project (16h): Implementation of a usual control law for a static converter in a microcontroller specialized in the control of electrical systems (DSC TI). - Configurable digital circuits (4h lecture (2x2h)) The elements covered will be: digital architectures according to the algorithms to be implemented, the representation and choice of the format of numbers, combinatorial logic, finite state machines, introduction to HDL languages, the structure of configurable digital circuits, FPGA, ASIC, CPLD, ... Project (16h): Implementation of a usual control law of a static converter in an FPGA circuit.

Total hours : 40
Lecture hours : 10
Tutorials hours : 20
Practical/lab hours : 10

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

Presentation (30 min) - Presentation of a choice of a detailed study carried out using the tools used in tutorials and/or practical work. The developments made beyond the exercises covered in the session, the quality of the slides and the oral presentation are assessed.

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. 2 or 3 industrial conferences are organized - during the lecture - to illustrate the concepts seen in lecture and tutorial with concrete cases - the associated problems are also presented. Tutorials (20h) Applications to concrete systems: Thermal power plant, Combined gas-steam cycle, Air conditioning, cold production, ... Influence of operating parameters on energy performance. Practical work (numerical) - 3 sessions of 3 hours + presentations Numerical simulation of energy systems and influence of operating parameters on their performance. Study of some optimization solutions.

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

Objective

Many natural phenomena and industrial processes involve heat and mass transfers at interfaces, whether solid/fluid or liquid/gaseous: transport of particles in fluids, evaporation of drops, cooling of hot walls, etc. Thus, the main objective of the EC aims to provide the methods and tools that allow these interfacial transfers to be characterized. The emphasis will be placed on the identification of flows and the establishment of energy balances but also on the analogy of the structure of the balance equations (balance of diffusive and convective phenomena) and therefore on the analogy of the modeling of mass and heat flows.

Skills acquired

Know how to characterize heat and mass transfers in the presence of solid/fluid or liquid/gaseous interfaces by identifying and modeling the flows involved.

Prerequisites

Thermodynamics S5 Fluid mechanics and applications S6 Introduction to heat transfers S7

Assessment

Exam to assess the level of knowledge in modeling interfacial heat and mass transfers. Assessment of knowledge acquired on transient heat transfers by an oral presentation based on one of the three proposed topics.

Teaching program

lecture: 5 sessions of 2 hours during which the following points will be covered Generalities and fundamental reminders: notion of balance and control volume, internal energy equations, coupling of dynamic and thermal boundary layers, Heat transfer by convection: Nusselt number, usual correlations for frequent cases (flat plate, penstock) Mass transfers: phenomenological description and analogy with heat transfer, properties of mixtures, Fick's law, balance equation of conservation of species, tutorial: 4 sessions of 2 hours devoted to solving exercises and concrete problems to apply the concepts seen in class lab work: 3 sessions of 4 hours. The sessions are organized in the form of a project where groups of students will address in detail one of the three subjects proposed around heat transfer in transient regime. The originality of these projects is that it allows students to study the problems under the experimental, theoretical and numerical simulation aspects. At the end of this project, students are asked to present their results during a presentation of approximately fifteen minutes.

Total hours : 10
Lecture hours : 6
Tutorials hours : 4
Practical/lab hours : 0

Objective

Many energy conversion systems are rotating machines (turbines, wind turbines, centrifugal compressors). The objective is to present the principles of fluid action on the rotor and to know how to model them. The goal is to be able to make the connection between rotor geometry and energy conversion optimization.

Skills acquired

• Model fluid actions on a blade or vane of a rotor of a rotating machine • Predict operating characteristics and optimize them using aerodynamics • Size a rotating machine while respecting specifications

Prerequisites

The Fundamentals of Mechanics (S5), Applied Mechanics (S6), Energy Conversion (S7)

Assessment

Skills in sizing a rotor taking into account specifications will be assessed by a mini-group project.

Teaching program

1. Consideration of rotor geometry in estimating converted power 2. Application to wind turbines: blade element theory (taking into account rotation effect and blade geometry) 3. Application to a centrifugal compressor

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

Objective

Turbulence is an essential area of fluid mechanics for engineers wishing to model industrial flows. It is the origin, among other things, of the intensification of heat and mass transfers. The physical foundations of turbulent flows will be presented to students to enable them to estimate the essential properties of this type of flow. We will also present the statistical description models on which many numerical simulation codes used in industry are based. The objective is to enable engineering students to make wise choices for modeling turbulent flows.

Skills acquired

Understand the physical mechanisms of a turbulent flow (turbulence scales, energy cascade) - Analyze and model a turbulent flow using a statistical description - Understand concrete problems, establish models and validate them. - Identify and model certain intensification mechanisms.

Prerequisites

Fundamentals of Mechanics (S5), Applied Mechanics (S6)

Assessment

We will focus on assessing students' understanding of fundamental mechanisms and their ability to analyze and model turbulent flow. This assessment will be done both through participation in tutorials and during the final assessment (exam).

Teaching program

The detailed program envisaged is as follows: - Physics of turbulence (scale of turbulence, Kolmogorov cascade, turbulent dissipation) - Statistical description of turbulence (Reynolds decomposition, averaged turbulence equations) - First order closure models (at 0, one or two equations) - Turbulent boundary layer We will focus in the TDs on illustrating the fundamental notions on concrete applications (jet flow, mixing layer, etc.).

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

Objective

This EC presents and develops the fundamental notions of fluid mechanics in relation to flows around solid objects.

Skills acquired

Calculation and analysis of flows around solid objects. Calculation of the forces exerted by a flow on an object.

Prerequisites

The Fundamentals of Mechanics (S5) and Applied Mechanics (S6) teaching units.

Assessment

Examination of the concepts seen in class and the analysis of a practical flow case.

Teaching program

This EC will cover the following topics: - aerodynamic concepts; - flow models; - dynamic boundary layer; - potential flows and vorticity. Tutorial sessions will complement the course as well as practical work sessions from the EC "Case Study".

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

Objective

The objective is to familiarize students with the physical mechanisms that couple the simultaneous movements of fluids and solids. We will base our studies on dimensional analysis, which will highlight the different types of coupling. The concepts covered in class will allow engineering students to understand concrete problems arising from various applications: aeronautics, biomechanics, transportation, and even the energy sector (nuclear, marine, wind, etc.).

Skills acquired

- Understand the concepts of coupling between fluid mechanics and structural mechanics. - Identify coupled physical mechanisms. - Understand concrete problems, establish models and validate them.

Prerequisites

Fundamentals of Mechanics (S5), Applied Mechanics (S6)

Assessment

The assessment will consist of a final written exam.

Teaching program

The proposed program should cover a wide range of effects in fluid-structure interactions that couple the simultaneous movements of fluids and solids. A particular effort will be made on weak couplings allowing easier immersion in this teaching. The detailed program is as follows: - Reminders of the equations of fluid mechanics, solids and boundary conditions. - Dimensional analysis of the equations and highlighting the coupling parameters (tutorial). - Weak coupling dominated by the solid: added mass, added stiffness, sloshing (tutorial). - Weak coupling dominated by the fluid: aeroelasticity, static and dynamic instability of a wing (tutorial). - Pseudo-static coupling: flutter, gallop (tutorial) - introduction to strong coupling: effect of turbulence, wake. The TDs will focus on the practical application of the course on concrete cases.

Total hours : 20
Lecture hours : 2
Tutorials hours : 0
Practical/lab hours : 18

Objective

The objective of this EC is to confront engineering students with the issues of the ECs of the block through experimental and numerical approaches. For each theme, two practical exercises (one numerical, one experimental) will be proposed. One of the important points is to allow a thorough confrontation between the concepts seen in class, experimental and numerical data. It will also involve deepening the numerical and experimental methods associated with fluid mechanics.

Skills acquired

- Data acquisition. - Modeling and comparison of experiments/models, - Oral and written restitution. - In-depth study of numerical methods. - In-depth study of experimental methods.

Prerequisites

Fundamentals of Mechanics (S5), Applied Mechanics (S6)

Assessment

The assessment consists of writing session reports. Students will also be assessed on their analytical skills during the session.

Teaching program

The EC includes a two-hour conference from an industrialist in one of the EC fields. The remaining hours (18h00) will allow the following program to be carried out, allowing the practical application of the concepts seen in the EC of the block: 1) Incompressible aerodynamics: - Simulation of flow around a wing profile. Calculation of aerodynamic coefficients. (3h00). - Wind tunnel tests on an aircraft wing and measurement of aerodynamic coefficients (3h00). 2) Turbulence: - Statistical description of a turbulent plane jet (3h00) - Experimental characterization of a turbulent plane jet (3h00). 3) Fluid-structure interaction: - Numerical simulation of an aeroelasticity problem (3h00). - Experimental characterization of aeroelastic instability in a wind tunnel (3h00). 4) Industrial conference on a block theme (2h00)

EC 8JENRJ6(	Computer Aided Design	UE 8JUNRJ06 8-06 Design and dimensioning of solids and structures	M.Bordron

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

Objective

To teach students the basic concepts of mechanical design and familiarize them with digital design tools using CATIA software. Introduce basic design rules and good CAD reflexes. Link design and production methods to connect the design to a physical reality full of constraints. Use the CATIA digital tool, first in a guided manner, then independently in the form of a mini-project. Design of simple and complex mechanical parts, assembly of parts.

Skills acquired

Design a part or a part assembly in 3D using a computer-aided design tool. Design a part from a diagram, a 2D plan, and/or specifications. Take into account the production/manufacturing constraints of these parts in their design. Integrate the principle of eco-design into part design. Work collaboratively on the design of a system.

Prerequisites

None

Assessment

Missing information

Teaching program

TP1 (4h): Reading/creating a 2D plan, presentation of the CATIA tool and first use. Designing a part from a plan. TP2 (4h): Designing a part from specifications. Respecting good design habits and using a skeleton. TP3 (4h): Designing a machined part from a blank. Flexible design and assembly. Using an external skeleton. Parameterization and catalog. TP4 (4h): Flexible assembly of a 4-cylinder engine and engine animation. TP5 (4h): Collaborative group project on a system of your choice, respecting the design rules learned during the other practical work.

Total hours : 10
Lecture hours : 6
Tutorials hours : 4
Practical/lab hours : 0

Objective

This module aims to present to students the historical and current issues concerning the production, use and intelligent recycling of materials concerning the extraction, production, transport, use and intelligent recycling of materials involved in recent systems and processes. The "life cycle" approach on several examples of materials and products will be approached through several points of view: Their technical performances, Their economic cost, Their environmental cost, Their societal cost; and different sectors: Energy, ICT, Building / construction, transport, transformation

Skills acquired

Calculate a Performance Index; Know how to make a choice of materials for a given product or a subsystem providing a function in a more complex system, Know how to select a technological solution that compromises several contradictory requirements; Understand the Environmental Balance (e.g. carbon footprint) of a product/sub-product; Address the Criticality of raw materials and certain geopolitical indicators; Design a product with an emphasis on its lifespan and aging by selecting wear parts in an informed manner

Prerequisites

Basic properties of materials (Common Core: materials for energy) Dimensioning criteria and study of constraints (Common Core)

Assessment

Evaluation of work on life cycle analyses carried out by students on given products or materials.

Teaching program

Missing information

Total hours : 20
Lecture hours : 10
Tutorials hours : 2
Practical/lab hours : 8

Objective

Provide students with a cultural foundation on technical solutions and design processes essential to the system design thinking process. Encourage students to choose a process or technical solution. Practice sizing technical solutions in context.

Skills acquired

Recognize or choose a process for a given situation, among the processes for shaping materials (by melting, by removal or by deformation of the material). Compare shaping processes for the same situation. Recognize/identify different technical solutions for mechanisms. Size a technical solution for transmitting a movement.

Prerequisites

None

Assessment

Writing and reporting for the BE

Teaching program

CM1 (2h): Technical vocabulary and transmission parts. Introduction to parts production. Forming processes by material deformation. CM2 (2h): Forming processes by material removal and melting. CM3 (2h): Material treatment processes. CM4 (2h): Improvement of existing processes and recent processes. tutorial (2h): Cost of machining a part, profitability study. BE1 (4h): 2-stage reducer. Retro-engineering, dimensioning of shaft, key, teeth. BE2 (4h): Agricultural vehicle coupling. Dimensioning of a transmission by cardan and spline. Study and addition of a reduction stage for the vehicle's power take-off.

Total hours : 20
Lecture hours : 2
Tutorials hours : 0
Practical/lab hours : 18

Objective

This module is dedicated to putting into practice the theoretical knowledge acquired through the study of a problem in solid mechanics, by imagining and developing several experimental, theoretical and numerical approaches. It involves establishing a work plan and imagining the experimental protocol using solid metrology tools. The entire technical platform of the department and the necessary digital resources are made available to students.

Skills acquired

At the end of this module, students will have learned to successfully carry out a case study in groups based on a clearly established work plan, striving to compare experimentation with modeling.

Prerequisites

Solid and structural mechanics courses for semesters S5, S6 and S7.

Assessment

Oral presentation relating to the situation

Teaching program

Case study taking place over four four-hour sessions. The work is conducted in pairs or threes and results in an oral presentation, followed by questions and discussions. The assessment takes into account the work completed during the sessions and the final presentation.

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

Objective

Industrial systems have become a prime target for cyber attacks due to their criticality and in many situations, these systems are not sufficiently protected against computer attacks. In this EC, we identify the risks in terms of cyber attack on an industrial system in order to identify and implement protective barriers using cryptographic methods and cybersecurity tools (detection and defense).

Skills acquired

Apply a cryptographic system to protect data and information - Analyze the risks of cyber attacks on an industrial system - Implement defense barriers (perimeter and in depth)

Prerequisites

Python programming, Communication networks, Sensor networks/IoT

Assessment

- Know how to apply and choose a cryptographic system to protect data and information - Know how to analyze and identify the risks of cyber attacks and implement defense barriers in an industrial application case. Assessment methods: 50% written exam + 50% practical work notes

Teaching program

Course: - Cryptographic system: symmetric, asymmetric encryption, and hash functions - Analysis of cyber risk in industrial systems (IEC 62443 standard): attacks and threats - Protection system: intrusion detection, firewall Tutorials: - Study of cryptographic systems Practical work: - Simulation with an industrial application case (ENSEM Cyber suitcase platform) to identify and remedy attacks on the control of an industrial system (SCADA and control automation)

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

Objective

This course offers a system/global vision of a digital architecture based on embedded components or sensors, means of transmitting information via a network. This course covers the fundamental concepts of distributed systems (exclusion, synchronization, coordination) and different solutions (technological or conceptual) to these. The practical applications focus on the construction of a complete information processing chain by a distributed system based on web services and blockchain technologies: acquisition, transmission, storage and analysis.

Skills acquired

Identify the major classes of distributed systems algorithms Implement solutions and algorithms in an integrative framework

Prerequisites

Algorithms and programming, Machine architecture, sensor network/IoT, embedded system

Assessment

Continuous assessment at the end of each practical session

Teaching program

Course (8h = 4x 2) Problem statement (exclusion, time synchronization, distributed system) Tools for distributed systems (semaphore, monitor, etc.) Blockchain technologies (structures and components, consensus mechanism) Web services Integrative practical work: 12 (4 sessions) H Theme: Create an information acquisition chain from sensors, transmission, storage, and then analysis. The objective is to create a distributed application for monitoring an electrical system. The application allows access to a physical system to retrieve data, distribute and share computing tasks between several participants, synthesize these calculations, and finally publish the average values of measured quantities in a blockchain in a “secure and traceable” form. We have an electrical system with several loads on which measurements must be taken and made available via a web service. Sequencing practical work 1: preparation and sharing of calculations in a master-slave architecture. lab work 2: access to the electrical system to collect data, lab work 3: implementation of a web service TP4: publication of data in a simplified Blockchain Keywords: Distributed architecture, blockchain, web service, digital acquisition chain

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

Objective

Discrete event system (DES) dynamics is characterized by discrete state variables and changes caused by external stimuli. They are therefore present in many industrial applications such as transportation systems, production systems, computer systems, communication systems, etc. This EC provides the scientific basis for the modeling and analysis of DES.

Skills acquired

At the end of this course, students will be able to: - model any system characterized by discrete event systems-type behavior, - analyze its properties, particularly those relating to safety or liveliness - design the control of an discrete event systems and analyze its performance

Prerequisites

This EC complements the theoretical foundations acquired in the ENSEM 1A common core (Boolean Algebra, Language Theory, Finite State Automata).

Assessment

- Written (theoretical knowledge on the analysis of RdP and skills in modeling discrete event systems) - Role-play through the modeling and analysis of a case study (oral defense of the work carried out in practical work).

Teaching program

Generalized Petri Nets: syntax and semantics, property analysis (liveness, blocking, marking and crossing invariants), marking graph, tree and coverage graph, - Colored Petri Nets - Non-autonomous Petri Nets: Timed Petri Nets (formalism, stationary regime, average crossing frequency, average marking), Interpreted Petri Nets - Performance evaluation of DES modeled by colored Petri Nets (CPN) - CPN Tools software.

Total hours : 20
Lecture hours : 10
Tutorials hours : 4
Practical/lab hours : 6

Objective

Systems used in the fields of energy and mobility (electrical energy production and transport systems, energy storage in its various forms, transport systems) must meet reliability and/or availability requirements in order to be safe in their operation. This EC introduces the fundamental concepts of Operational Safety (OS) and shows any engineer that the failure of a system is not inevitable and that it is possible to determine the causes of failures and assess their impact on performance. The EC addresses the modeling and analysis of the OS of systems using different formalisms, highlighting their complementarity.

Skills acquired

At the end of this EC, students will be able to: • analyze a system from a dysfunctional point of view • evaluate the reliability of components • model systems in order to probabilistically evaluate their operational safety

Prerequisites

Knowledge of mechanical, electrical and automated physical systems and their operating principles, as taught in the common core ECs of the 1st and 2nd years - EC "Modeling of Discrete Event Systems (discrete event systems)", 1st year, S5 - EC "Probabilities and statistics", 1st year, S6

Assessment

Written and practical work report

Teaching program

Lectures (5CM*2h): • Concepts and definitions: reliability, availability, maintainability, safety (RAMS), MTTF, MTBF, MTTR • Component reliability • Combinatorial approaches for modeling and evaluating the reliability of systems: - reliability block diagrams (RBD) - fault trees (AdD) • State-transition approaches for modeling and evaluating the reliability of systems: - Markov chains (CoM): reliability, availability or maintainability models, state probability distribution, evaluation of reliability indicators Tutorials (2TD*2h): • modeling and analysis of non-repairable systems by RBD and AdD • modeling and analysis of repairable systems by CoM Practical work (2TP*3h): • probabilistic evaluation of non-repairable systems by RBD and AdD (Grif software) • probabilistic evaluation of systems repairable/reconfigurable by CdM (Grif software)

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

Objective

Digital telecommunications are expanding rapidly, and technological means are becoming increasingly efficient to deliver the expected services. This course aims to describe information transmission techniques (particularly those using digital modulation), information quantification and coding, and compression methods.

Skills acquired

- Coding and compression of information in lossy and lossless signals. - Principles of the baseband and transposed carrier transmission chain.

Prerequisites

ENSEM Signal Processing Course

Assessment

Written and practical work report

Teaching program

Course 1. Information theory in the sense of Shannon 2. Source and channel coding 3. Notions of error detection and correction codes 4. Principle of compression algorithms: application to images 5. Review of the underlying mathematical tools: DCT, wavelets 6. Notion of quantization 7. Modeling of data transmission in baseband and transposed band 8. Single-carrier digital modulation: ASK, FSK, PSK, quadrature with M states MQAM, with a large number of carriers OFDM 9. Channel sharing modeling: FDMA, TDMA, CDMA 10. General structure of a digital communication device: 5G, WIFI, TNT applications Tutorials 1. Entropy calculation, coding, Shannon-Fano and Huffman algorithms 2. Compression: JPEG and JPEG 2000 (on machine) Practical work 1. Baseband transmission, filtering Keywords: Modulation techniques, information theory, signal compression.

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

Objective

The Internet of Things (IoT) is generating more and more data, the storage and exploitation of which require an efficient management system. This course covers the design and exploitation of relational databases, as well as SQL querying via dedicated interfaces or connectors with other computer languages for more flexible exploitation (e.g., Python). It also introduces the use of structured XML documents. Finally, it provides an introduction to noSQL databases for Big Data management.

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 (Python)

Assessment

Written and practical work report

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 (eg MongoDB) Tutorials: 1. Conceptual Data Model (CDM), Logical Data Model (LDM) and Relational Algebra 2. SQL Queries 3. XML 4. NoSQL Practical work: 1. Design, implementation and querying of a MySQL database 2. Querying a MySQL database via the Python connector 3. Implementation of XML data: structuring, parsing and presenting documents 4. NoSQL Databases (MongoDB) Keywords: Database, Entity/association model, relational model, SQL, XML, big data, NoSQL.

EC 8JENRJ92	Implementing an Internet of Things application	UE 8JUNRJ09 8-08 Signals, Data and the IoT	?

Total hours : 20
Lecture hours : 2
Tutorials hours : 0
Practical/lab hours : 18

Objective

The objective of this EC is to acquire skills through practice through the implementation of a complete "collection-transmission-storage-exploitation" type solution for telemetry data using Internet of Things techniques and computer communication networks applied to an energy system.

Skills acquired

- Integrate a technical solution for collecting-transmitting-storing-exploiting telemetry data - Model and structure telemetry data - Expose and exploit the collected data to derive indicators

Prerequisites

Algorithms and programming (1A), Signal processing (2A), Sensor networks (2A)

Assessment

Know how to develop and integrate into a system a telemetry application based on Internet of Things technologies Assessment methods: report and defense of completed projects

Teaching program

This EC is carried out in the form of a design office to build in an incremental and integrative way the solution envisaged on a case study chosen by the students (microgrid, Internet of energies, smart building, connected vehicle): - Data acquisition via sensors and their associated protocols (Zigbee, WiFi, LoRa) - Data compression and protection - Data transmission via a wireless sensor network - Data structuring and storage in a database (SQL/NoSQL) - Data distribution (eg MQTT) - Analysis and pre-processing of data/signals

Total hours : 20
Lecture hours : 10
Tutorials hours : 4
Practical/lab hours : 6

Objective

The proliferation of embedded computing devices has played a decisive role in the widespread implementation of digital control systems at the industrial and scientific levels. The objective of this course is to introduce the basic concepts enabling the analysis and design of digital control laws. Particular attention will be paid to the consideration of sampled data and the analysis of phenomena specific to digital control. Applications in tutorial/lab work focus on the practical problems of digital / analog interfaces and digital servoing.

Skills acquired

Master the basic concepts of digital control. Understand the phenomena specific to digital control. Know how to design digital control and analyze its performance.

Prerequisites

First-year automation course, basic concepts of signal processing (sampling, z-transform) and mathematics, particularly linear algebra.

Assessment

Written and practical work report

Teaching program

Introduction to digital control Analog-to-digital and digital-to-analog conversion Frequency approach: Z-transfer function Stability analysis Discretization of analog correctors Synthesis of digital correctors State-space approach: Exact discretization. Stability, controllability, observability. Synthesis of control laws by state feedback. Phenomena specific to digital control Effect of the sampling period on structural properties Quantization, Anti-aliasing filter References: K.J. Astrom, B. Wittenmark, Computer-Controlled Systems: Theory and Design, Prentice Hall. Katsuhiko Ogata, Discrete-time control systems, Prentice Hall.

Total hours : 18
Lecture hours : 10
Tutorials hours : 4
Practical/lab hours : 4

Objective

The objective of this course is to provide the skills to analyze the stability of dynamic systems, a fundamental property of automation, which ensures the convergence of system variables towards desired values while guaranteeing robustness. Methods for synthesizing control laws are also presented.

Skills acquired

Stability analysis Controller synthesis Lyapunov theory Simulations under Matlab-Simulink

Prerequisites

Mathematics at the 1st cycle level in science or preparatory classes for the grandes écoles in science. First-year automatic control courses.

Assessment

Written and practical work report

Teaching program

Introduction Representation of dynamic systems Stability and analysis Stabilization lab work: Distributed control of a fleet of autonomous cars under Matlab-Simulink

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

Objective

Industrial infrastructures rely heavily on time-constrained systems to monitor and control their associated processes. These systems rely on embedded, real-time applications to perform their control and command operations. The objective of this EC is to identify and implement technical solutions based on microcontrollers to develop these applications.

Skills acquired

- Identify the time constraints of an application and model the scheduling of its tasks - Implement and integrate a real-time, embedded application on a hardware target

Prerequisites

Algorithms and programming (1A)

Assessment

- Know how to study and analyze the time constraints of a real-time application - Know how to implement and integrate a real-time application Assessment methods: Practical work notes (50%), Written exam (50%)

Teaching program

Course (8h) - Introduction to C programming - Real-time systems and scheduling algorithms - Interrupts, input/output management, PWM signals and timers - Real-time executives: FreeRTOS, Xenomai Practical work (12h) - C programming on microcontrollers - Simulation analysis of the task scheduling of a real-time application - Integration and implementation of an application on a hardware target (Arduino, FreeRTOS)

EC 8JENR10	Smart grid application	UE 8JUNRJ10 8-09 Stability, Control and Digital Integration	J. Daafouz

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

Objective

Interconnected dynamic systems such as smart grids or multi-agent systems, whether social or technical, pose control and optimization challenges related to their coupled, distributed, and large-scale nature combined with limited communication and computing capabilities. The objective of this course is to raise awareness among future engineers about the control and optimization problems of interconnected dynamic systems as they apply to smart grids.

Skills acquired

Modeling, analysis and control of interconnected dynamic systems.

Prerequisites

Basic concepts in automation, optimization, electrical circuits and power electronics

Assessment

Written and practical work report

Teaching program

Introduction Modeling of interconnected systems and multi-agent systems Stability of interconnected systems Synthesis of distributed control laws Practical work: Application of consensus algorithms to the control of DC microgrids and optimization of electric vehicle charging. References: F. Bullo. Lectures on Network Systems, Kindle Direct Publishing, 2022.

Total hours : 24
Lecture hours : 12
Tutorials hours : 12
Practical/lab hours : 0

Objective

The objective of this course is to introduce basic techniques in multivariate data analysis and pattern recognition. After introducing the notions of individual and characteristics, the first part presents methods for representing multidimensional data in reduced-dimensional spaces (Principal Component Analysis). The second part of the module will introduce decision theory, and supervised or unsupervised classification methods based on probabilistic data modeling will be presented.

Skills acquired

Ability to analyze and interpret large-scale data. - Expertise in implementing classification algorithms in the presence or absence of labeled data.

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 (S5)

Assessment

Evaluation based on report

Teaching program

Lectures - Introduction to principal component analysis for data representation. Variables and individuals, correlation circles. - Unsupervised classification 1. Distances and aggregation methods, dendrogram, inconsistency coefficient. K-means algorithm. - Decision theory, Linear and quadratic discriminant analysis. - Supervised classification. Estimation of unparameterized and parameterized probability densities. - Unsupervised classification 2. Mixture of Gaussians, review of k-means. Practical work on a computer machine using Matlab - 10-hour mini-project. The objective is to take charge of a realistic data set and apply the different approaches presented, as well as to prepare for EC4 of this skills block (Design Office).

Total hours : 12
Lecture hours : 6
Tutorials hours : 6
Practical/lab hours : 0

Objective

The EC is dedicated to the presentation of kernel methods. These allow the conversion of most linear learning methods into methods suitable for the search for nonlinear regularities while retaining most of the advantages of linear methods: ease of implementation and good theoretical foundations. A particular focus will be made through the SVM (Support Vector Machine) classification method which is one of the most used.

Skills acquired

Ability to manipulate large data sets and extract relevant information - Proficiency in implementing basic techniques - Proficiency in parameterizing and using a subset of data analysis functions

Prerequisites

- Basic notions of linear algebra (matrix calculus, eigenspace, projection) (S5) - Basic notions of optimization (S6) - Basic elements of probability and statistics (S7)

Assessment

The final grade is the grade of the detailed report on the various tutorials with an analysis of the results obtained for each of the situations.

Teaching program

Lectures - Presentation of the SVM method in the case of linearly separable data - Introduction of slack variables to deal with the case of linearly non-separable data - Concept of kernel and related properties - Transposition from the linear case to the non-linear case by the "kernel trick" Practical work on a computer machine - Complete programming of the method in the linear case and application to toy examples - Programming of kernel SVMs

Total hours : 12
Lecture hours : 6
Tutorials hours : 6
Practical/lab hours : 0

Objective

This EC is an introduction to neural networks. After introducing the similarity with biological neurons, a presentation of the perceptron is made for a simple binary output. An extension for more complicated cases is presented with the multi-layer perceptron (MLP). In a second step, the convolutional neural network used for image classification is introduced. For the unsupervised context, autoencoders and Kohonen maps are introduced. These neural networks can be used for classification, pattern recognition, feature extraction, etc.

Skills acquired

- Ability to manipulate algorithms and parameterize them correctly - Ability to classify high-dimensional data. - Ability to distinguish and differentiate between different types of neural networks and use them in supervised and unsupervised learning cases

Prerequisites

- Basic notions of linear algebra (matrix calculus, eigenspace, projection) (S5) - Basic notions of optimization (S6) - Basic elements of probability and statistics (S7)

Assessment

The final grade is the grade of the detailed report on the various tutorials with an analysis of the results obtained for each of the situations.

Teaching program

Lectures - Introduction to the perceptron, and extension to the multi-layer perceptron with the implementation of the back propagation algorithm - Introduction to the convolutional neural network used in the case of image processing - Unsupervised classification: introduction of autoencoders with the two parts: encoders and decoders with the algorithms necessary to create the encoder-decoder sequence - Introduction of the Kohonen map used to produce a low dimension for the discretized representation of the input space of the training samples Practical work on a computer machine - Complete programming of the backpropagation algorithm - Application of the different approaches presented to toy examples

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

Objective

The objective of this research office is to apply, evaluate and compare the different data analysis techniques presented in this skills block. The targeted application is pedestrian detection in images, a current problem for autonomous vehicles. An image database made available by INRIA is used, and contains images with the presence and absence of pedestrians for training and testing the models seen in class.

Skills acquired

- Ability to formalize and process a problem on real data, from feature extraction to classification - Ability to evaluate different processing methods, to choose and argue one's choice - Ability to prototype a processing chain (under Matlab)

Prerequisites

Knowledge acquired in the other three ECs of the skills block, Matlab language

Assessment

Evaluation based on report

Teaching program

Machine Learning - Feature Extraction - Data Reduction and Discriminant Analysis - SVM - Neural Networks

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

Objective

The aim of this EC is to study the theoretical aspects of low-frequency electromagnetism problems. After seeing how to model and solve problems analytically, we will study the tools for numerically solving more complex problems by presenting the particularities of the finite element method applied to low-frequency electromagnetism problems. The applications studied in tutorial and lab work will be a large number of devices: passive components (capacitors, inductors, etc.), induction heating, magnetic couplings, eddy current brakes, etc.

Skills acquired

To be able to understand low-frequency electromagnetism problems and analytically solve classical academic cases. To know the strong formulations of electromagnetism in the approximation of quasi-stationary regimes and to be able to deduce the associated weak forms. To master the particularities of the field: boundary conditions corresponding to the treatment of distant boundaries, types of elements (mixed = nodal / edge / facet elements), particular gauge conditions, potential formulations. To be able to interpret, adapt and modify a model developed with the free software interface ONELAB (Gmsh and GetDP).

Prerequisites

None

Assessment

Microproject enabling the resolution of a concrete engineering problem using a suitable digital code.

Teaching program

Course: (8 x 2h) (http://cours.jufont.net/ensem/mef-emag) Part I: Electromagnetism CM1: EM fields, Behavior laws, Maxwell's equations CM2: ARQS, Potentials, Global laws CM3: Interface and boundary conditions, Global quantities: energies CM4: Global quantities: fluxes and forces CM5: Magnetoharmonic, Strong formulations in BF electromagnetism Part II: MEF CM6: Continuous model, Discrete model, Galerkin method, Mesh CM7: Nodal basis functions, Resolution, Whitney elements CM8: Weak formulations in BF electromagnetism * tutorial: (4 x 2h) TD1: Classical academic exercises (plane and cylindrical capacitors), infinite wire, coaxial cable TD2: Electromagnet TD3: Notch of a MAS (leakage inductance and resistance as a function of frequency) TD4 : Induction heating of a brass cylinder * lab work: (4 x 4h) TP1: Gmsh/GetDP tutorials where we will simulate the examples of tutorial TP2: Thermal coupling of TD4 & Magnet coupling TP3&4: Microproject

Total hours : 40
Lecture hours : 4
Tutorials hours : 0
Practical/lab hours : 36

Objective

The objective of this EC is to learn to master two "business-oriented" finite element calculation software programs in low-frequency electromagnetism. The applications studied in practical work are classic devices of Electrical Engineering: electromagnets, transport cables, transformers, induction heating inductors and electrical machines.

Skills acquired

Know how to pose an electromagnetism problem in the approximation of quasi-stationary regimes and implement it in the two reference finite element calculation codes: FEMM (freeware) and Altair® FLUX® (commercial). Know and master the particularities of the field. Know how to control FEMM via Matlab / GNU Octave or Python to solve 2D problems in magnetostatics and magnetoharmonics. Know how to define more advanced complete problems in Altair Flux (2D/3D, magnetostatics / harmonics / transients, couplings with circuit or thermal equations).

Prerequisites

None.

Assessment

Case study and simulation to study and size electromechanical devices.

Teaching program

Course: (2 x 2h) CM1: How to properly define a problem in a “business” software: choice of formulation, mesh, boundary conditions, taking into account symmetries and periodicities. CM2: Presentation of Altair® FLUX® (by an Altair representative, former student of the school). * Practical work: (9 x 4h) Part I: FEMM (4 x 4h) (https://cours.jufont.net/ensem/lab work-femm/) Practical work 1: Tutorials for getting started (Coil, Magnet) Practical work 2: Magnetic suction cup Practical work 3: Induction heating Practical work 4: MSAP Part II: Altair Flux (5 x 4h) Practical work 1 & 2: Single-phase transformer: 2D/3D, static / harmonic / transient, Circuit coupling, characteristic tests (parameter identification) Practical work 3 & 4: Three-phase submarine cable: Circuit coupling, thermal coupling, shielding and insulation concepts Practical work 5: Magnet coupler: magnetic scalar potential, 2D/3D, reduction of the study area

Total hours : 28
Lecture hours : 8
Tutorials hours : 0
Practical/lab hours : 20

Objective

The aim of this course is to understand and implement numerical methods and schemes such as Finite Volumes (used in Fluent or Openfoam) and Finite Elements (used in Abaqus, Comsol Multiphysics or FlexPDE) for solving problems in Mechanics: Thermal, fluid and solid mechanics.

Skills acquired

Model a physical problem using PDEs, and know how to discretize them using VF and EF methods to put them into matrix form for resolution. Choose the most suitable methods for solving a given problem in terms of stability and accuracy. Know how to solve a problem written in PDE form in a commercial multi-physics code.

Prerequisites

Basic numerical analysis course 1A, applied mathematics course (distributions, variational analysis, PDE, etc.) and common core courses in thermal engineering, fluid and solid mechanics.

Assessment

A series of practical exercises to validate the implementation of numerical schemes seen in class. Learn how to numerically solve PDEs in Thermal, Fluid and Solid Mechanics using VF & EF methods under Matlab and FlexPDE.

Teaching program

Finite Volumes (2H lecture): - Formulation and discretization of conductive and convective flows (linear, Upwind and Quick) - Resolution of a conducto-convective type problem (heat or mass). Finite Elements (4H lecture): - Weak Variational Formulation - Discrete and matrix form of the problem - Resolution of a viscous flow or elasticity type problem (stresses and deformations) FlexPDE (2H lecture): - Presentation of the multiphysics finite element software FlexPDE. 20 H lab work (Setting up diagrams - Volumes & 2D Finite Elements on 2 concrete physical problems and use of the commercial code FlexPDE). 3 TPs of 4 hours = 12 TPs on Matlab. 2 TPs of 4 hours = 8 TPs on FlexPDE. The courses allow you to prepare the numerical schemes that will be implemented in Matlab and the physical problems with their modeling in the form of partial differential equations for FlexPDE practical work. The practical work will focus on the implementation of the problems seen in the course: 3 practical work on Matlab and 2 practical work on FlexPDE. The examples covered concern thermal (2D), fluid mechanics (Poiseuille and Couette flows) and/or elastic solid mechanics (2D).

Total hours : 26
Lecture hours : 6
Tutorials hours : 0
Practical/lab hours : 20

Objective

The objective of this course is to provide fundamental notions concerning the resolution of the heat equation and the Navier-Stokes equation in fluid mechanics for engineers. The different types of PDEs are discussed (elliptic, parabolic and hyperbolic) as well as their physical interpretation. Since the resolution methods are based on the correspondence between a differential operator and a matrix operator, we show how the inversion of very large matrices (for example those used to model the internet or large neural networks) is a necessary knowledge for solving modern engineering problems.

Skills acquired

Classification of PDEs and adapted resolution methods. Discretization of the heat equation and creation of the corresponding matrix operator. Inversion algorithm for large matrices (including multigrid methods). Application to the PageRank algorithm for classifying Google websites. Application to the calculation of heat exchangers and to the Pressure-Velocity coupling in computational fluid mechanics. CAD coupling - Fluid Mechanics and Computational Thermal Engineering.

Prerequisites

1st year Fluid Mechanics and 2nd year Thermal Engineering. Elementary numerical analysis (Jacobi and Gauss-Seidel methods) Matrix algebra (CPGE level).

Assessment

Students will be graded in session (Fluent practical work) and via the Matlab grader application for the sessions dedicated to it.

Teaching program

Lectures (6hCM) CM1: Review of partial differential equations and their resolution method. Finite volume method applied to fluid mechanics: pressure-velocity coupling. CM2: Meshing technique for an industrial part, quality and "mesh" specifications. CM3: Solving the Laplace/Heat equation and Inversion of large matrices using the multigrid method. TP1: Calculation of a heat exchanger using the finite volume method with Matlab TP2: Solving the 1D heat equation using the Jacobi and Gauss Seidel methods with Matlab TP3: Solving the 2D heat equation using the Jacobi method with Matlab TP4: Weighted Jacobi method and multigrid method using Matlab. TP5: CAD using Ansys Workbench, Meshing and Simulation using Ansys Fluent

Total hours : 26
Lecture hours : 6
Tutorials hours : 0
Practical/lab hours : 20

Objective

The objective of this EC is to study the specificities of the finite element method applied to solid mechanics, using it to analyze the behavior of machines and structures for the purpose of designing them. Despite the variety of existing commercial solutions, the ABAQUS calculation code will be used as a tool to illustrate the possibilities offered by this resolution method for machines and structures. Applications will concern the themes of energy production/storage as well as the field of transport.

Skills acquired

The different skills associated with this EC will be: 1) The establishment of a data set allowing the study of constraints, deformations and vibratory behavior of machines and structures 2) The understanding of the different critical aspects of modeling influencing the quality of the solution 3) The critical analysis of the results of these simulations with regard to the hypotheses formulated 4) The application of the approach for the dimensioning of machines and structures

Prerequisites

The concepts from the EC of continuous media mechanics (S5) and mechanics for the engineer (S6) will be used and considered acquired. The classic resolution schemes seen in numerical analysis will also be an asset to understand the theoretical part of this course. NB: aspects related to Computer Aided Design (CAD) will be covered in an additional block "Eco-design for energy and mobility".

Assessment

The course assessment is based on a calculation grade to be submitted at the end of the last practical work of the EC.

Teaching program

With the exception of an introduction to the specificities of the finite element method in its application to solid mechanics in the form of lectures, the EC will mainly consist of practical work on computers. In accordance with current industrial and societal issues, all application cases will concern energy storage and production or transport. In a 6-hour lecture format, the following points will be covered: - Presentation of the method and areas of application - Example of direct resolution for a plane lattice - Extension to the general and three-dimensional case for solving a linear problem - Choice of element type and good practice manual - Introduction to sources of non-linearities and solving concrete problems The 20 hours of practical work that will follow will be divided as follows: - TP1: study of a lattice (modeling hypotheses, quality of the approximate solution, dimensioning) - TP2: study of a hydroelectric dam (convergence to the mesh, quantitative analysis, 2D vs 3D) - TP3: study of a flywheel (geometries of revolution, anisotropy, stress concentration) - TP4: study of tire/road contact (contact modeling, assemblies, loading sequence) - TP5 (assessed): variable subject of one year to the other The practical work subjects will be posted on the ARCHE platform as the course progresses, as well as a complete course document concerning the finite element analysis of machines and structures.

EC 8JENR14	H2 electrochemical systems	UE 8JUNRJ14 8-H2 Hydrogen Track: From Production to Energy Applications	G. Sdanghi

Total hours : 42
Lecture hours : 42
Tutorials hours : 0
Practical/lab hours : 0

Objective

Becoming familiar with electrochemical systems for hydrogen production and their energy use

Skills acquired

Basic principles of electrochemistry applied to hydrogen systemsHydrogen production by water electrolysis/compressionUses of hydrogenSizing and characterisation of a fuel cell system (PEM type)Management and control of a hybrid-powered drivetrain

Prerequisites

Thermodynamics - Material transfer and thermal energy transferElectrical engineering

Assessment

Continuous assessment

Teaching program

Part 1: H2 sector: current status and ambitions for the futurePart 2: Electrochemistry and characterisation methods for H2 systemsPart 3: Fuel cells (PEMFC)Part 4: H2 production and storagePart 5: Electrical architecture of H2 electrochemical systems

Total hours : 38
Lecture hours : 0
Tutorials hours : 0
Practical/lab hours : 38

Objective

Becoming familiar with electrochemical systems for hydrogen production and their energy use

Skills acquired

Basic principles of electrochemistry applied to hydrogen systemsHydrogen production by water electrolysis/compressionUses of hydrogenSizing and characterisation of a fuel cell system (PEM type)Management and control of a hybrid-powered drivetrain

Prerequisites

Thermodynamics - Material transfer and thermal energy transferElectrical engineering

Assessment

Work during sessions and oral presentation

Teaching program

- Digital practical work (8 hours): Modelling an H2 fuel cell system using Matlab/Sim - Impedance spectroscopy- Experimental practical work (20 hours): Fuel cells and hybridisation – Study of an electrolyser - Assembly and testing of a single PEMFC cell- Case studies (10 hours)

EC 8JE47N2.	Fundamentals of Nuclear Energy (FST)	*UE 8JUNRJ15 8-Nuclear-1 Nuclear Training – Core Curriculum*	*X. Caron*

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

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

Total hours : 18
Lecture hours : 18
Tutorials hours : 0
Practical/lab hours : 0

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

EC 8JENR15	Digital Methods & Tools	UE 8JUNRJ15 8-Nuclear-1 Nuclear Training – Core Curriculum	N. Rimbert

Total hours : 42
Lecture hours : 6
Tutorials hours : 0
Practical/lab hours : 36

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

EC 8JENR16	Thermo-Hydraulics	*UE 8JUNRJ16 8-Nuclear-2 Nuclear Training - Mechanics & Energy*	*A. Labergue*

Total hours : 20
Lecture hours : 10
Tutorials hours : 4
Practical/lab hours : 6

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

EC 8JENR16	**Turbulence (nuclear formation)**	*UE 8JUNRJ16 8-Nuclear-2 Nuclear Training - Mechanics & Energy*	*O. Caballina*

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

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

EC 8JENR16	Heat networks & thermodynamic systems	UE 8JUNRJ16 8-Nuclear-2 Nuclear Training - Mechanics & Energy	B. Remy

Total hours : 20
Lecture hours : 6
Tutorials hours : 6
Practical/lab hours : 8

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

EC 8JENR16	**Multiphysical behavior of materials, stress corrosion cracking**	*UE 8JUNRJ16 8-Nuclear-2 Nuclear Training - Mechanics & Energy*	*JF. Ganghoffer*

Total hours : 20
Lecture hours : 16
Tutorials hours : 4
Practical/lab hours : 0

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

EC 8JENR17	Transient regimes of synchronous alternators	UE 8JUNRJ17 8-Nuclear-3 Nuclear Training - Electrical Engineering	N. Takorabet

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

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

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

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

EC 8JENR17	Modeling and control of electrical machines	UE 8JUNRJ17 8-Nuclear-3 Nuclear Training - Electrical Engineering	F. Meibody-Tabar

Total hours : 40
Lecture hours : 20
Tutorials hours : 12
Practical/lab hours : 8

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

EC 8JENR18	Cryptography, Cybersecurity of industrial systems	UE 8JUNRJ18 8-Nuclear-4 Nuclear Training - Information Sciences	?

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

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

EC 8JENR18	Operational safety (nuclear training)	UE 8JUNRJ18 8-Nuclear-4 Nuclear Training - Information Sciences	N. Brinzei

Total hours : 20
Lecture hours : 10
Tutorials hours : 4
Practical/lab hours : 6

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

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

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

EC 8JENR18	**Stability and stabilization of systems (nuclear training)**	*UE 8JUNRJ18 8-Nuclear-4 Nuclear Training - Information Sciences*	*R. Postoyan*

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

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Missing information

EC	Projects (foreign students)	UE Projects (foreign students)	S. Gallaire

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

ECOLE NATIONALE SUPERIEURE
D'ELECTRICITE ET DE MECANIQUE
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Academic year 2025-2026
Detailed curriculum 2025-2026 NRJ_FISE

Semester S9

Code	Course Unit	ECTS	Code	Course	Coeff	Teacher	Vol	CM	TD	TP
			9KEFGN61	Bank English	0,5	*C. Corringer*	**24**		24	0
			9KEFGN64	Professional integration	0,5	*F. Temsamani*	**30**	15	15	0
			9KEFGN65	Energy research	pass/fail	*B. Remy*	**20**	20	0	0
9KUFGN06	General Training 5	**5**	9KEFGN67	Validation of international experience	pass/fail	*S. Gallaire*	**1**	0	1	0
			9KEFGN51	Academic R&D Project - Industrial R&D Project	0,6	*J.-C. Perrin*	**60**	0	0	60
9KUFGN15	Project	**5**	9KEFGN52	Cross-functional design office	0,4	*T. Boileau / V. Louis-Dorr*	**30**	0	0	30
			9KENRJ91	Risk analysis and functional security	0,5	*N. Brinzei*	**30**	18	4	8
9KUNRJ09	9_1 Risk analysis and monitoring of energy systems	**5**	9KENRJ92	Monitoring and Diagnosis	0,5	*S. Maza*	**30**	20	10	0
			9KENRJ10	Inverse problems, Decompositions, Parsimony	0,3333	*R. Ranta*	**20**	10	10	0
			9KENRJ11	Pattern identification and reduction	0,3333	*M.Giaccagli*	**20**	12	8	0
9KUNRJ11	9_2 Modeling and Analysis of Electromechanical Systems using Data-Based Ap	**5**	9KENRJ12	Design offices	0,3333	*M. Giaccagli / R. Ranta*	**20**	0	0	20
			9KENR270	Event Control	0,3333	*R. Postoyan*	**20**	8	4	8
			9KENR271	Optimal Control and Reinforcement Learning	0,3333	*J. Daafouz*	**20**	8	4	8
9KUNRJ27	9_3 Event Control and Reinforcement Learning	**5**	9KENR272	Design offices	0,3333	*J. Daafouz / R. Postoyan*	**20**	0	0	20
			9KENR280	Control over the challenges of transport and conversion	0,5	*J. Kreiss*	**30**	0	30	0
9KUNRJ28	9_4 Control of energy and transport systems	**5**	9KENR281	Nuclear control and Component-based automation	0,5	*J.-F. Pétin*	**30**	6	2	22
			9KENRJ30	Electrical energy quality - Static and dynamic stability	0,5	*S. Pierfederici*	**30**	14	0	16
9KUNRJ13	9_5 Autonomous and on-board electrical networks	**5**	9KENRJ31	Energy management in microgrids	0,5	*J.-P. Martin*	**30**	16	2	12
			9KENR290	Analytical modeling and optimization of electrical machines	0,5	*D. Netter*	**30**	0	0	30
9KUNRJ29	9_6 Electrical Machines (modeling & design)	**5**	9KENR291	Optimization and design of electrical machines	0,5	*N. Takorabet*	**30**	16	2	12
			9KENRJ50	High Availability Electromechanical Conversion - Part 1	0,5	*F. Meibody*	**30**	22	0	8
9KUNRJ15	9_7 Electromechanical Conversion with High-Availability	**5**	9KENRJ51	High Availability Electromechanical Conversion - Part 2	0,5	*T. Boileau*	**30**	14	0	16
			9KENRJ60	Power semiconductor components	0,5	*St. Rael*	**30**	22	0	8
9KUNRJ16	9_8 ETNP components in their environment	**5**	9KENRJ61	Electromagnetic compatibility	0,5	*M.Urbain*	**30**	14	0	16
			9KENRJ70	Electrochemical storage of electrical energy	0,5	*M.Hinaje*	**30**	18	0	12
9KUNRJ17	9_9 Electrical storage systems	**5**	9KENRJ71	Interface power electronics converters	0,5	*S. Pierfederici*	**30**	14	0	16
			9KENRJ80	P-HIL - tools and techniques	0,5	*E. Jamshidpour*	**30**	10	0	20
9KUNRJ18	9_10 "Power-Hardware-In-The-Loop" (P-HIL)	**5**	9KENRJ81	P-HIL Project	0,5	*C.-H. Bonnard*	**30**	0	10	20
			?	High-speed flows and combustion conversion	?	*F. Lemoine*	**25**	25	0	0
			?	Multiphase flows and interfaces	?	*N. Rimbert*	**20**	14	0	6
?	9_11 Advanced Fluid Mechanics	**5**	?	Turbulence modeling	?	*O. Caballina*	**15**	10	0	5
			?	Heat exchangers and waste heat recovery	0,3333	*N. Rimbert*	**20**	20	0	0
			?	Flow in complex media	0,3333	*N. Louvet*	**20**	20	0	0
?	9_12 Heat and mass transfer	**5**	?	Heat transfers at interfaces and participating media	0,3333	*B. Remy*	**20**	20	0	0
			?	Methodology for characterizing	0,3333	*A. Labergue*	**20**	20	0	0
			?	Experimental characterization	0,3333	*G. Pernot*	**20**	0	0	20
?	9_13 Simulate, measure and visualize	**5**	?	Numerical simulations and applications	0,3333	*O. Caballina*	**20**	0	0	20
			?	Materials Science	0,3333	*M.Bordron*	**20**	8	4	8
?	9_14 Materials Science and Behavior	**5**	?	Mechanical behavior of materials	0,6667	*C. Laurent*	**40**	14	6	20
			?	Nuclear and Society (SHJEJS)	0,33	*?*	**14**	14	0	0
			?	Design and operation of nuclear installations	0,33	*?*	**28**	28	0	0
?	9_15 Nuclear	**5**	?	Advanced study	0,33	*?*	**18**	18	0	0
9KUETR06	Projects (foreign students)	**25**	9KUETR60	Projects (foreign students)	1	*S. Gallaire*				

Total hours : 24
Lecture hours :
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. OR B2 Support: this module is intended for students in difficulty who have not yet validated the B2 level. The objective is to enable them to achieve a minimum score of 785 on the TOEIC test or 100 on the DET.

Skills acquired

-Skills in written and oral expression and comprehension in relation to the engineering career -International and cultural openness -Teamwork OR Support B2: oral and written comprehension, identifying strengths/weaknesses, knowing how to set objectives, learning to learn

Prerequisites

Having reached a B2 level OR B2 support: having passed an external certification and not having validated the B2 level

Assessment

Continuous assessment (written work, oral participation) and final evaluation for each module.

Teaching program

first module of 7 sessions of 2 hours: Interacting Professionally OR B2 support A second module of 8 sessions of 2 hours: Scientific Communication OR B2 support The Interacting Professionally module aims to prepare students to apply in English for job offers (personal branding, CV, job interview), 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, 3MT, etc.) For B2 Support, students work on identifying their strengths and weaknesses. They establish a work plan in order to achieve a score of 785 on the TOEIC or 100 on the DET. They look for relevant resources allowing them to fill the identified gaps. The teacher helps students with their work, advises them and answers their questions. Regular exercises and tests allow students to structure and evaluate their progress.

EC 9KEFGN6	Professional integration	UE 9KUFGN06 General Training 5	F. Temsamani

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

Objective

•Support the engineering student in promoting their personal and professional project •Prepare their integration around professionals such as industrialists, entrepreneurs, human resources managers, and alumni.

Skills acquired

•Integrate and communicate in a professional environment. •Know and know how to use different tools for internship and job search. •Structure and optimize your job search. •Position yourself and use professional and digital networks. •Self-assess your skills.

Prerequisites

Advanced definition of the personal and professional project.

Assessment

Workshops 50% and interviews 50%

Teaching program

Day 1 - Plenary session with presentations and presentations from various ENSEM partners, including human resources professionals. Day 2 - Evaluation workshops with professionals on tools (CV, cover letter, motivation kit, interview preparation documents, etc.). Day 3 - Development of search strategies with professionals (management of professional networks, use of digital platforms, etc.). Day 4 - Interview simulations. Day 5 - Testimonials from alumni and further reflection on the personal and professional project (integration and career management).

EC 9KEFGN6	**Energy research**	*UE 9KUFGN06 General Training 5*	*B. Remy*

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

Objective

Understand R&D opportunities in the energy field and know how to project the knowledge acquired in training in an R&D-oriented framework.

Skills acquired

Understand R&D opportunities in the energy field and know how to project the knowledge acquired in training in an R&D-oriented framework.

Prerequisites

Engineering training

Assessment

Continuous Assessment - Participation in Conferences

Teaching program

Intervention by professionals from the industrial and R&D world.

EC 9KEFGN6	**Validation of international experience**	***UE 9KUFGN06 General Training 5***	***S. Gallaire***

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

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Mobility report to be submitted to Arche according to the imposed model

Teaching program

Missing information

Total hours : 60
Lecture hours : 0
Tutorials hours : 0
Practical/lab hours : 60

Objective

The objective of this final-year project is to enable engineering students to apply the knowledge acquired during their training at school to a concrete engineering research and development problem. The subject is proposed by a teacher or a company and students will work individually or in groups depending on the subject and the work required to meet the study specifications. Students will thus develop their reasoning and adaptation skills, in order to immerse themselves in a company during the engineering internship that will follow at the end of semester S9.

Skills acquired

Simulation of managing a large-scale engineering project.

Prerequisites

1A and 2A lessons.

Assessment

Oral defense and project report

Teaching program

Definition of project objectives Definition of specifications and expected results Functional and technical specifications Design and simulation of the proposed solution(s) Validations •

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

Objective

The objective of this educational activity is to conduct the study of a system in the form of a multidisciplinary design office in autonomy by group. Two applications are proposed. The first is the Urbanloop platform. Each year the subject evolves according to the technical and technological developments of the ENEDIS Urbanloop experimental circuit and its capsules. The second is the energy micro-grid platform. Each year the subject evolves according to the available and interconnectable energy production and consumption systems.

Skills acquired

Be able to implement a design and development project for a complex system and to implement multidisciplinary skills within the framework of managing a collaborative project.

Prerequisites

1A and 2A Electrical Engineering, 2A Emerging System Control, 1A and 2A Automation, 1A Solid Mechanics, 2A Fluid Mechanics

Assessment

We assess the ability to collaborate in a multidisciplinary context, to present work carried out independently, to present a scientific approach consisting of several phases: modeling, development, control and testing

Teaching program

Definition of project objectives Specifications and deliverables: Definition of specifications and expected results Functional and technical specifications Design and unit simulation of the different parts Development and unit tests Cross-validations Mid-term review Prototyping Technical integration of processes Presentation Demonstration

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)

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.

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

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

Objective

This course covers the fundamentals of model identification and reduction. It also includes an introduction to data-driven control. Using dynamic models from physics to describe system behavior with sufficient accuracy is not always possible, hence the need for data-driven approaches. Data-driven models are derived from observations and measurements of the real system and require minimal prior knowledge.

Skills acquired

Acquisition of basic methods for identifying linear systems. Mastery of basic model reduction methods.

Prerequisites

Knowledge acquired in ENSEM 1A and 2A common core training: First-year Automation course, first-year Mathematics.

Assessment

Assessment of skills acquired through practical applications

Teaching program

Under assumptions related to operating conditions, a linear model may be sufficient. A reduced order model will be preferred to facilitate the simulation, analysis and synthesis stages of control laws. The aim of this course is to introduce the basic notions of model identification and reduction and to raise students' awareness of the identification of nonlinear systems and data-based control Identification of linear systems: - Nonparametric methods - Parametric methods (linear regression, instrumental variable method, prediction error method, and statistical methods including maximum likelihood) - Least squares methods, - Recursive estimation, - Model validation. - Closed-loop identification Model reduction: classical reduction methods (projection, balanced truncation, singular perturbations), optimization-based methods Identification of nonlinear systems (NARMAX, SINDY) Introduction to data-based control. The tutorial sessions are organized around pedagogical examples in order to illustrate the concepts introduced in this course and to fully understand the advantages and limitations of the methods presented. Bibliography: L. Ljung System Identification - Theory for the user Prentice Hall, 1999. T. Soderstorm and P Stoica, System Identification (http://user.it.uu.se/~ts/sysidbook.pdf) Keywords: dynamic systems, identification, estimation, model reduction, optimization.

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

Objective

This design office is dedicated to the application of model identification and reduction methods on examples inspired by real-life applications. The general theme is the modeling of dynamic systems and data-driven control. The objective is to put students in real-life identification conditions and to be able to describe the general principles and identify systems satisfactorily. This includes an analysis of the choice of excitation signals, the model structure and the estimation algorithm as well as the appropriate use of model validation.

Skills acquired

Mastery of systems identification and model reduction methods.

Prerequisites

Knowledge acquired in the ENSEM 1A and 2A core curriculum: First-year Automation courses, First-year Mathematics. The inverse problems and system identification courses are essential prerequisites for taking this module.

Assessment

Evaluation on test cases

Teaching program

The program is planned in 5 sessions of 4 hours each. The first three sessions will be dedicated to case studies allowing the application of the concepts acquired in lectures and tutorials on model identification and reduction. The last two sessions will be devoted to a problem with data from a real process with a dual objective: to identify and validate the system model and to propose a control strategy. During these sessions, the Matlab identification toolbox will be used. Keywords: dynamic systems, identification, estimation, model reduction, optimization.

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

Objective

?

Skills acquired

?

Prerequisites

?

Assessment

?

Teaching program

?

EC 9KENR27	Optimal Control and Reinforcement Learning	UE 9KUNRJ27 9_3 Event Control and Reinforcement Learning	J. Daafouz

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

Objective

?

Skills acquired

?

Prerequisites

?

Assessment

?

Teaching program

?

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

Objective

?

Skills acquired

?

Prerequisites

?

Assessment

?

Teaching program

?

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)

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 component-based automation. The learning is carried out around case studies: control of a nuclear power plant using tools widely used in the industrial automation 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 DES automation 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 and component-based industrial automation, emulation of process and plant parts, digital simulation and formal verification of properties. Case studies : - Nuclear control (2 elementary systems of a "lego" power plant supplied by EDF). - Flexible Production Systems

EC 9KENRJ3	Electrical energy quality - Static and dynamic stability	UE 9KUNRJ13 9_5 Autonomous and on-board electrical networks	S. Pierfederici

Total hours : 30
Lecture hours : 14
Tutorials hours : 0
Practical/lab hours : 16

Objective

The objective of this module is, on the one hand, to learn how to model, control and dimension the main power structures to improve the quality of alternative electrical energy microgrids (THD voltage and current, voltage plan, frequency, load unbalance, voltage unbalance) using power electronic converters (STACOM, FACTS, active series-parallel filters). On the other hand, this course will analyze the dynamic stability of DC and AC microgrids. After detailing the modeling of this type of system, two tools will be implemented, namely impedance spectroscopy and the state approach for the analysis of stability and active stabilization of microgrids.

Skills acquired

Know how to model, size and implement electrical systems to improve network quality and guarantee their dynamic stability.

Prerequisites

Power electronics B4, network B1

Assessment

Note 1 = Note of TP1&2 - active filtering Note 2 = Note of TP2&3s - stability Note 3 = Exam (or project) note Final note = 0.3*Note 1 + 0.2*Note 2 + 0.5* Note 3

Teaching program

The different points covered are: Active filtering in AC microgrids (4h lecture, 4h TP1). FACTS-STACOM (2h lecture, 4TP2) Stability – Stabilization of microgrids (8h lecture, 8h TP3&4) TP1: experimental implementation of an active filter on a three-phase AC microgrid TP2: Control of the voltage plan on AC microgrids. TP3&4: Study by numerical simulation of a DC microgrid: stability and stabilization analysis, then experimental validation.

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

Objective

The objective of this module is to model, size and implement common electrical microgrid architectures associated with energy management algorithms of different natures. The constraints of the different sources and storage elements are taken into account to limit the aging of the system. For distributed microgrids, the hierarchical approach including the primary, secondary and tertiary control levels is introduced.

Skills acquired

Know how to model, size and implement AC and DC microgrids with their energy management system (EMS).

Prerequisites

Common core + modules B4 “Advanced power electronics structures for stationary and on-board applications” and B1 “Energy networks” from semester 8.

Assessment

Theoretical examination and evaluation of reports associated with the project and practical work.

Teaching program

The different points covered are: 1. Centralized management of microgrids (10h lecture, 2h tutorial). In order to obtain distributed, reversible electrical energy sources, combining high autonomy with a high level of power, the association of electrical sources and storage elements of different natures is necessary. Energy management between these different elements uses algorithms of a generally centralized nature taking into account the constraints of the different sources. They locally supply a set of loads and can include, if necessary, a connection device to another DC or AC electrical network. 2. Decentralized and distributed management of microgrids (6h lecture, 4h lab work) The association of different generators distributed via an AC or DC electrical network constitutes a distributed microgrid. Energy management between the different distributed generators uses algorithms that are generally decentralized or distributed by nature, and are controlled using local data or data exchanges through a low-speed communication network. Hierarchical control strategies and frequency filtering methods are also detailed. For distributed microgrids, the hierarchical approach including primary, secondary and tertiary control levels is introduced. Project (8h): Experimental implementation of a DC microgrid for avionics applications Practical work (4h): Numerical simulation study of the centralized and distributed management of AC microgrids.

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.

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

Total hours : 30
Lecture hours : 22
Tutorials hours : 0
Practical/lab hours : 8

Objective

The objective of the module is to study structures for combining electrical machines and high-availability power electronics. These are reliable and/or fault-tolerant structures. Models of these systems in normal and degraded operating modes (in the presence of faults) are presented. These structures are found in particular in aircraft rudders, offshore wind turbines, subsea pumps, hybrid vehicles, ship engines, submarine engines.

Skills acquired

Know the power supply structures and architectures of polyphase and multi-star machines according to their applications in embedded systems and in electrical power generation systems. Study the torque and current control of these machines in normal mode and in degraded modes following a fault. Understand the operation of fault-tolerant electromechanical conversion structures in their operating mode in normal mode and in fault mode. Some companies implementing these skills: SAFRAN, electrical engineering, Valéo, Garrett, IFP Energies Nouvelles, Naval Group….

Prerequisites

Electrical machines in S6 and S7; Power electronics in S6 and S7 and UE A2 of S8

Assessment

Project Report Evaluation and Review

Teaching program

lecture “120°” Command Study and modeling of polyphase and multi-star electrical machines Power supply and control structure of polyphase and multi-star machines Control strategy for fault-tolerant electrical drives in normal and degraded modes (in the presence of faults in electrical machines and power electronics) Project Implementation of a polyphase electromechanical conversion system tolerant to faults in normal mode and fault mode (degraded mode).

Total hours : 30
Lecture hours : 14
Tutorials hours : 0
Practical/lab hours : 16

Objective

The objective of the module is to study the consequences of the main faults that electromechanical conversion systems (power electronics and electrical machines) can suffer, as well as the methods that allow them to be detected (and to ensure the transition to degraded operating mode). These detection methods are found in particular in aircraft rudders, offshore wind turbines, subsea pumps, ship engines, etc.

Skills acquired

Knowledge of machine models and power electronic converters in the presence of faults. Knowledge of the different fault signatures of alternative electrical machines and application to the transition to degraded operating mode. Implementation of a control in the event of mechanical sensor failure. Some companies implementing these skills: SAFRAN, electrical engineering, Garrett, IFP Energies Nouvelles, Naval Group

Prerequisites

Electrical machines in S6 and S7; Power electronics in S6 and S7 and UE A2 of S8

Assessment

Evaluation of practical work and project reports and examination

Teaching program

lecture Study and modeling and detection of electrical machines in the presence of inter-stator turn short circuit. Study and modeling and fault detection of a three-phase inverter. Study and control of permanent magnet synchronous machines in the event of absence or failure of the mechanical sensor. Industrial case study of the implementation of fault detection of electrical machines lab work Implementation of the control of permanent magnet synchronous machines in the event of absence or failure of the mechanical sensor. Project Study and implementation and fault detection of an electromechanical conversion chain, the project can be coupled with the EC: Block B15-S9-1

EC 9KENRJ6	Power semiconductor components	UE 9KUNRJ16 9_8 ETNP components in their environment	St. Rael

Total hours : 30
Lecture hours : 22
Tutorials hours : 0
Practical/lab hours : 8

Objective

Static conversion of electrical energy relies on the implementation of power electronic components, and therefore requires detailed knowledge of the operating principles of these devices, their constraints, and their limits. The objective of this EC is to provide students with this knowledge necessary for the design and sizing of static converters, to understand current technologies (silicon-based), and the technologies of the future (large gap semiconductor materials, SiC and GaN in particular).

Skills acquired

Elements of knowledge on power semiconductor components, required for the design of a power electronics converter: - Knowledge of the static and dynamic behavior of the main power semiconductor switches - Evaluation of the electrical constraints and losses of the components of a power system - Implementation of power semiconductor components, in particular gate transistors

Prerequisites

Tools for electricity and electronics (S5) Power electronics (S6 and S7)

Assessment

- Two-hour written exam without documents - coefficient 1/2 - Practical work report - coefficient 1/2

Teaching program

Course: 22 hours - Semiconductor physics: at thermodynamic equilibrium, out of thermodynamic equilibrium - Basic semiconductor functions: voltage withstand, resistivity modulation, gate control, MOSFET transistor effect - Operating principles of the main power semiconductor components: structure, equivalent diagram, static characteristic, dynamic behavior - Environment: encapsulation, switching cell, control, cooling - Modeling under Saber Practical work: 8 hours - Experimental studies of the operation of a power transistor (power MOS transistor or insulated gate bipolar transistor) - Static characteristics: plotting VI characteristics, measuring internal resistance, measuring the threshold voltage for conduction. Influence of gate voltage, temperature, technology (digital sciences, SiC) - Switching waveforms: identification and duration of switching phases, dynamic losses, influence of control (on speed, losses, overvoltages, recovery of the diode associated with the transistor), influence of wiring, measurement of parasitic inductance

Total hours : 30
Lecture hours : 14
Tutorials hours : 0
Practical/lab hours : 16

Objective

Power electronic converters are essential for many everyday systems (transport, renewable energy, power supply, etc.), and power semiconductors are their basic element. Technological advances (switching speed, switching frequency, etc.) have made it possible to significantly increase their energy density with excellent efficiency. On the other hand, these converters are the source of increasing electromagnetic pollution (conducted disturbances, harmonics, radiated field) incompatible with standards and can also excite resonance modes in traction chains. Preventive and curative methods exist (shielding, filtering, control), and this course is the subject of these methods.

Skills acquired

At the end of this course, students will have acquired the knowledge required to take into account EMC phenomena upstream of the design of a conversion chain. Understand (origin and manifestation) and formalize EMC phenomena (putting into equations), represent power electronic converters taking into account high-frequency phenomena, suggest a solution against conducted disturbances.

Prerequisites

S6 and S7 power electronics

Assessment

Written exam without documents - coefficient 1/2 Project report - coefficient 1/2

Teaching program

Course 1 (7 hours): EMC for DC/DC devices (Matthieu Urbain) 1. Case study: the real series chopper and its high-frequency imperfections 1.1. origins and manifestations of imperfections 1.2. propagation of harmonics in the environment 1.3. high-frequency model of the switching cell 2. The RSIL device 2.1. definition of common mode and differential mode 2.2. EMC standards 2.3. acquisition of disturbances using RSIL 3. Study of a commercial EMC filter 3.1. constitution of the filter and setting into equations 3.2. Frequency behavior and expected attenuation Course 2 (7 hours): EMC for AC devices (Thierry Boileau) 1. Physics of high-frequency electrical circuits (ARQS limit) 2. High-frequency modeling of wound circuits 3. Modeling of a three-phase electrical machine at high frequencies using its common-mode and differential-mode impedances 4. Filtering of conducted electromagnetic disturbances in converter-three-phase electrical machine associations Practical work: 16 hours TP1. Study of a common-mode and differential-mode filter for chopper • Waveforms in switching, • Acquisition of common-mode and differential-mode disturbances • Influence of the control, • Measurement of attenuation and comparison with the expected TP2. Project "Study of the frequency and time response of a coil at high frequency" TP3. Project "Dimensioning of common-mode and differential-mode filters for a three-phase load"

Total hours : 30
Lecture hours : 18
Tutorials hours : 0
Practical/lab hours : 12

Objective

Electricity production is diversifying and gradually moving towards primary renewable sources, the large-scale deployment of which will require managing the intermittency of these sources through electrical energy storage solutions. The transport sector, and particularly that of private vehicles, is moving towards increasing electrification, with the need to use electrical energy storage.

Skills acquired

Know how to model, characterize and size electrochemical electricity storage systems (supercapacitors, batteries) and devices related to the hydrogen vector (fuel cells and electrolysers).

Prerequisites

None

Assessment

Practical work report

Teaching program

The objective of this EC is to provide students with the necessary theoretical foundations and prerequisites for the design, sizing and management of electrochemical electrical energy storage systems, the implementation of which is envisaged both in electrical networks and for the field of mobility. Emphasis will be placed on the general operating principles, physical modeling (for knowledge of the intimate operation and associated limits) and global modeling (for energy management and in-situ estimation) of batteries (lithium-ion technologies, in particular), supercapacitors, and devices relating to the hydrogen vector, fuel cells and electrolysers. - Basic concepts in electrochemistry: electric double layer, redox reaction, electrode potential, electrochemical kinetics and electrode overvoltages, charge and material transport, diffusion impedances - Electrochemical accumulators: definitions, principles, battery technologies (lead acid, alkaline, lithium-ion), batteries of the future - Lithium-ion battery: principles, technologies, physical modeling, global modeling, state of charge, health, function - Fuel cell and battery system: battery technologies, PEM battery: operating principle, constitution, static and dynamic behavior, physicochemical modeling, external modeling - Supercapacitors: principle, technologies, physical modeling, external modeling, applications and implementation TP1: Modeling of a lithium-ion battery TP2: Characterization of supercapacitors TP3: Characterization of a hybrid fuel cell-supercapacitor source. Keywords: electrochemical storage, batteries, supercapacitors, hydrogen

Total hours : 30
Lecture hours : 14
Tutorials hours : 0
Practical/lab hours : 16

Objective

The objective of this EC is to enable students to master the conversion structures serving as an interface between storage systems and DC or AC energy networks. The modeling will integrate parasitic elements such as inductances in multi-winding structures, inter-turn parasitic capacitances, EsR resistances, iron losses in magnetic circuits, and semiconductor switching.

Skills acquired

Know how to model, size and implement static converters by integrating parasitic elements

Prerequisites

S7 Power Electronics

Assessment

Grade 1 = Grade for TP1&2&3&4 Grade 2 = Grade for exam (or project) Final grade = 0.4*Grade 1 + 0.6*Grade 2

Teaching program

The following will be studied in this module: - high power AC/DC conversion for low voltage - high current DC applications - isolated DC/DC conversion with integration of parasitic elements: in particular, quasi-resonant isolated structures, passive and active clamping circuits, Dual Active Bridge, multi-port, current fed isolated converter topologies will be studied, as well as the principle of partial power converters and power structures allowing the balancing of battery cells (BMS) The course plan is as follows: 1. High power step-down AC/DC conversion (2h lecture, 4h lab work). 2. Isolated converters (12h lecture, 12h lab work) TP1: Study by digital simulation of a three-phase AC DC step-down converter TP2: Sizing and implementation of a switching power supply with active clamping circuit TP3: Digital simulation of an isolated converter of the current fed isolated DC DC converter type TP4: Study, sizing and digital simulation of a converter used in a BMS (Battery management System)

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.

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 ?	High-speed flows and combustion conversion	UE ? 9_11 Advanced Fluid Mechanics	F. Lemoine

Total hours : 25
Lecture hours : 25
Tutorials hours : 0
Practical/lab hours : 0

Objective

At the intersection of fluid mechanics and thermodynamics, this field explores complex yet essential phenomena in many cutting-edge sectors. You will discover how these flows are involved in aircraft aerodynamics, engine operation (turbojets, thrusters, rocket engines), and large energy infrastructures. The challenges of energy conversion will also be addressed, particularly those related to the use of decarbonized fuels, the formation of pollutants, and the basics of combustion, through the study of laminar flames and premixed flames.

Skills acquired

- Know how to calculate a compressible flow (including with shock wave) with a simplified theory. - Be able to calculate a compressible flow in a pipe with pressure loss or heat transfer. - Know the basics of the operation and calculation of aeronautical turbomachines - Know the new fuels/combustibles (hydrogen, biomass, ammonia) - Master the basics of combustion thermochemistry, the basics of flame theory - Know the main pollutants resulting from combustion and their formation mechanisms

Prerequisites

Basics of fluid mechanics (incompressible domain, basics of thermodynamics (1st and 2nd principle)

Assessment

Exercises to be submitted by working group - Mini project with report and oral presentation

Teaching program

The course adopts a hybrid format combining pre-recorded online sessions, to be followed at your own pace, and in-person sessions focused on exchange, clarification of concepts and practical application. The fundamental concepts will be introduced beforehand, accompanied by exercises to be prepared, the correction and discussion of which will take place in class. You will explore the basics of compressible flows: Mach number, compressibility of gases, speed of sound... These key concepts will allow you to approach an initial modeling: the one-dimensional theory of compressible flows, including cases with or without pressure drops or heat transfers. The modeling of normal shock waves will also be covered, which will allow you to understand the transition between supersonic and subsonic regimes. The concepts will be applied to the context of aeronautical turbomachinery, offering a concrete illustration and a natural transition to the theme of energy conversion by combustion. The fundamentals of thermochemistry necessary for understanding combustion phenomena will be introduced, along with an overview of new carbon-free or carbon-neutral fuels. The course will also cover the formation of pollutants resulting from combustion, particularly greenhouse gases. Finally, the course will conclude with the foundations of flame theory—in premixed and diffusion regimes.

EC ?	Multiphase flows and interfaces	UE ? 9_11 Advanced Fluid Mechanics	N. Rimbert

Total hours : 20
Lecture hours : 14
Tutorials hours : 0
Practical/lab hours : 6

Objective

This course is mainly focused on the concept of interface between two fluids (although fluid/solid interfaces are also discussed). The aim here is to detail the concept of interfacial tension, from its microscopic origin to its macroscopic interpretation. The applications here are the concept of wetting or the shape of droplets. The modeling of multiphase flows is then approached by extending the concept of integral balance seen in the first year to multiphase cases. We deduce the concept of "jump condition" at the interface which will be essential for approaching the modeling of phase changes.

Skills acquired

Surface tension and interfacial tension Theoretical modeling of multiphase flows Numerical modeling of multiphase flows

Prerequisites

First-year fluid mechanics. Finite volume methods

Assessment

The assessment is made through the submission of a design office report on the analytical and numerical calculation with the Fluent software of the Kelvin-Helmholtz instability.

Teaching program

The course is divided into six parts 1- Concept of surface tension 2- Balance equation in multiphase 3- Jump condition at interfaces 4- Macroscopic modeling of multiphase flows (Eulerian, Eulerian/Eulerian, Eulerian/Lagrangian) 5- Numerical methods: a) finite volume method (reminder) b) VOF/PLIC method for monitoring the interface c) CSF Continuum Surface Force (CSF) method for discretizing interfacial forces 6- Flow maps and pressure drops in multiphase lab work (2x3h): Kelvin-Helmholtz instability and appearance of waves on a sheared interface. Theory and CFD calculations with Fluent.

EC ?	Turbulence modeling	*UE ? 9_11 Advanced Fluid Mechanics*	*O. Caballina*

Total hours : 15
Lecture hours : 10
Tutorials hours : 0
Practical/lab hours : 5

Objective

Turbulence modeling is essential for understanding and predicting the complex flows encountered in many industrial applications. It allows for optimizing system performance while reducing the costs associated with experimental testing through numerical simulations. In sectors such as aeronautics, energy, and automotive, it helps design more efficient and durable equipment. Course objectives: Acquire the basics of turbulence, understand the main models (RANS, LES, etc.), know how to apply them to industrial cases, and interpret the results to guide design.

Skills acquired

Understanding of turbulent phenomena Mastery of turbulence models and their fields of application. Use of simulation tools: Competence in the use of calculation software (CFD) to simulate turbulent flows in an industrial context. Critical analysis of results: Ability to interpret simulation results, assess their reliability and draw relevant conclusions.

Prerequisites

Applied Mechanics (S6), UE Fluid Mechanics for Engineers (S8), UE Modeling & Numerical Simulation in Thermal, Fluid and Solid Mechanics (S8)

Assessment

Report on the lab work project under Fluent

Teaching program

Turbulence models RANS (k-ε, k-ω), LES, DNS, limits and comparisons Turbulent dispersion (pollutants, heat, chemical species) Numerical simulation (CFD) Simulation tools, meshing, model implementation Applied project / practical work Complete case study with simulation, analysis and report

EC ?	Heat exchangers and waste heat recovery	*UE ? 9_12 Heat and mass transfer*	***N. Rimbert***

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

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 part. Waste heat recovery will be addressed (overall context, methodology and technologies).

Skills acquired

Sizing a heat exchanger, choosing the method, and order of magnitude. Introduction to phase-change heat exchangers (evaporators, condensers). Knowledge of waste heat sources, recovery technologies, and comparison and evaluation methodologies.

Prerequisites

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

Assessment

The assessment is carried out for the exchanger part via a final examination to which is added a design office report. The assessment of the fatal heat recovery part consists of the submission of a project report.

Teaching program

heat exchanger (N. Rimbert) 1- Sizing of co-current and counter-current exchangers by the NUT and DTLM method 2- Useful correlations in heat transfer in exchangers 3- Extension of the NUT and DTLM method to other exchanger configurations 4- Case of evaporators and condensers Recovery of fatal heat (F. Lemoine) 1- The heat vector in the world 2- Methodology for evaluating fatal heat deposits, concepts of exergy 3- Technologies for recovering fatal heat at different temperature levels 4- An example: nuclear cogeneration

EC ?	**Flow in complex media**	*UE ? 9_12 Heat and mass transfer*	*N. Louvet*

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

Objective

This EC aims to present the particularities of mass and heat transfer in porous media. The rather "physical" approach will allow for the simplest possible description of flow and dispersion mechanisms. The course content will lead us to analyze concrete industrial cases.

Skills acquired

- Describe a porous medium, - Model a flow problem in a porous medium, - Analyze experimental results, - propose characterization methods.

Prerequisites

Fluid mechanics and heat transfer of S7 and S8

Assessment

Table exam

Teaching program

The course aims to understand mass and heat transfers in porous media. To this end, the program will cover the following points: - description of a porous medium: porosity, tortuosity, specific surface area. - capillary effects: Laplace pressure, Jurin's law, Kelvin's law, sorption isotherm. - Flows in porous media: Darcy's law, permeability, hydrodynamic dispersion. - Opening towards coupled mass/heat transfers. - Experimental characterizations of porous media. - Study of application cases.

EC ?	Heat transfers at interfaces and participating media	UE ? 9_12 Heat and mass transfer	B. Remy

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

Objective

Know how to model heat transfers at interfaces - Know how to model coupled conducto-convecto-radiative heat transfers in participating media in dense media and media with high and low porosity

Skills acquired

- Know how to extend the exchange coefficient notation in unsteady cases and for non-uniform wall temperatures and fluxes. - Know how to model coupled transfers (conduction, convection and radiation) in participating media in the form of equivalent conductivity. - Implementation of the PN method on a commercial numerical simulation code.

Prerequisites

S7 Common Core Thermal Course

Assessment

Continuous assessment based on results obtained on Matlab and FlexPDE applications

Teaching program

This course is composed of two parts of 10 hours each. - The first concerns the modeling of transfers at interfaces. This involves extending the concept of Newton's exchange coefficient in the unsteady case and for non-uniform wall temperatures and fluxes. Applications on concrete industrial cases will be studied and implemented on Matlab. - The second part concerns the modeling of coupled transfers (conduction, convection and radiation) in the case of participating media and porous media with high and low parosity such as mullite used in the design of catalytic pots, porous volume absorbers based on SiC used in concentrated solar tower reactors or AZS (Alumina, Zirconia and Silica) used in porous volume absorbers for the recovery of fatal heat in energy-intensive processes (metallurgy, glassmaking, cement works, etc.). We will focus on the modeling of these coupled transfers using the concept of equivalent conductivity, the non-intrinsic nature of which will be demonstrated, and the modeling of these transfers using the 3D PN method (polynomial approximation), which provides an excellent compromise between the accuracy of the results and the speed of the calculations. This type of approach will be implemented in commercial codes such as FlexPDE and COMSOL MULTIPHYSICS. The results will be compared with results obtained using detailed discrete ordinate models.

EC ?	Methodology for characterizing	UE ? 9_13 Simulate, measure and visualize	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 ?	Experimental characterization	UE ? 9_13 Simulate, measure and visualize	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 ?	Numerical simulations and applications	*UE ? 9_13 Simulate, measure and visualize*	*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 ?	Materials Science	UE ? 9_14 Materials Science and Behavior	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 ?	Mechanical behavior of materials	UE ? 9_14 Materials Science and Behavior	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 ?	**Nuclear and Society (SHJEJS)**	*UE ? 9_15 Nuclear*	*?*

Total hours : 14
Lecture hours : 14
Tutorials hours : 0
Practical/lab hours : 0

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Educational program: - Radiation/matter interaction (1 hour) - Principles of radiation protection (3 hours) - Regulation of nuclear power and its stakeholders (ASN, IRSN) (2 hours) - Nuclear accidents (3 hours) - Positioning and future of the sector, economic model (2 hours) - Nuclear power and ethics (3 hours)

EC ?	**Design and operation of nuclear installations**	*UE ? 9_15 Nuclear*	*?*

Total hours : 28
Lecture hours : 28
Tutorials hours : 0
Practical/lab hours : 0

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Educational program: - Power plant components (4 hours) - Materials (3 hours) - Development and manufacturing (6 hours) - Operation and control (8 hours) - Operating safety (7 hours) - Cattenom visit

EC ?	**Advanced study**	*UE ? 9_15 Nuclear*	*?*

Total hours : 18
Lecture hours : 18
Tutorials hours : 0
Practical/lab hours : 0

Objective

Missing information

Skills acquired

Missing information

Prerequisites

Missing information

Assessment

Missing information

Teaching program

Educational program: - Energy (6 hours) - Electrical (6 hours) - Digital (6 hours)

EC 9KUETR6 **Projects (foreign students)** *UE 9KUETR06 Projects (foreign students)* *S. Gallaire*

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

ECOLE NATIONALE SUPERIEURE
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Academic year 2025-2026
Detailed curriculum 2025-2026 NRJ_FISE

Semester S10

Code	Course Unit	**ECTS**	Code	Course	Coeff	*Teacher*	**Vol**	CM	TD	TP
0KSTAG01	Engineering or R&D Internship	**30**	0KSTAGE3	Engineering Internship	1					

EC 0KSTAGE **Engineering Internship** *UE 0KSTAG01 Engineering or R&D Internship*

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