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 ISN_FISE

Semester S5

Code	Course Unit	ECTS	Code	Course	Coeff	Teacher	Vol	CM	TD	TP
			5JESNN30	Complex Analysis	0,34	*B. Florentin*	**20**	10	10	0
5JUSNN03	Mathematics 1	**5**	5JESNN31	Mathematics for engineers	0,66	*A. Gueudin*	**32**	16	16	0
			5JESNN41	Electrical Circuits and Applications	0,32	*M.Hinaje*	**40**	18	14	8
			5JESNN40	Modeling of Signals, Systems and Link Graphs	0,28	*V. Louis-Dorr*	**30**	14	6	10
5JUSNN04	Signals, Systems and Electrical Circuits	**10**	5JESNN42	Analytical Modeling in Mechanics and Electricity	0,4	*A. Pereira*	**40**	20	20	0
			5JESNN50	Algorithms and programming	0,44	*?*	**30**	7	5	18
5JUSNN05	Information Sciences 1	**5**	5JESNN51	Discrete Mathematics	0,56	*J.-F. Pétin*	**40**	22	18	0
			5JESNN20	English	0,5	*C. Corringer*	**24**	0	24	0
			5JESNN21	Modern languages 2	0,5	*A. Quesada*	**24**	0	24	0
5JUSNN02	Languages 1	**5**	5JESNN22	Validation of the French language clearance certificate	pass/fail	*A. Quesada*	**1**	1	0	0
			5JESNN11	Business environment	0,3	*F.Temsamani*	**20**	14	6	0
			5JESNN13	Electrical authorization and occupational health	pass/fail	*T. Boileau*	**8**	8	0	0
			5JESNN15	CSR 1	pass/fail	*V. Louis-Dorr*	**11**	2	9	0
			5JESNN17	Industrial conferences	pass/fail	*P. Villette*	**6**	6	0	0
			5JESNN12	Communication	0,3	*A. Thimon*	**16**	0	16	0
			5JESNN14	Project management	0,4	*J.-C. Marpeau*	**18**	2	16	0
5JUSNN01	General Training 1	**5**	5JESNN14	1st year project	pass/fail	*J.-C. Marpeau*	**30**	0	0	30

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

Objective

This module focuses more on new concepts from complex analysis. The concepts covered are more challenging and require significant in-depth work and mathematical manipulations carried out in tutorials.

Skills acquired

Mastery of complex variable functions and the links between harmonicity and holomorphy

Prerequisites

Preparatory class program.

Assessment

One grade in November (NN) and one grade in January (NJ). The final grade (NF) is obtained by the formula: NF=0.4*NN+0.6*NJ

Teaching program

Complex differentiability; Holomorphism; Connection with conformal transformations; Curvilinear integrals; Cauchy's theorem and integral formula; Connection between harmonicity and holomorphism; Analytic functions; Complex trigonometry; Logarithmic function; Analytic functions; Singularities of holomorphic functions; Residue theorem.

EC 5JESNN3	Mathematics for engineers	UE 5JUSNN03 Mathematics 1	A. Gueudin

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.

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

Objective

Review of methods for studying electrical circuits in steady state (continuous and sinusoidal). Presentation of methods for studying transient conditions. These study methods will be implemented in various applications such as instrumentation, power electronics, and electrical energy transmission networks.

Skills acquired

Mastery of methods for studying single-phase and three-phase electrical circuits (including power calculations) Knowledge of electronic circuit associations ensuring correct operation. Analysis at different levels of a static converter

Prerequisites

Physics program for preparatory classes for Grandes Écoles MP, PC, PSI.

Assessment

T: grade obtained on the test and the graded tutorial. E: grade obtained on the exam NP: average of the grades from the lab work reports NT: max((2E+T)/3, E), Final grade: 0.8*NT+ 0.2*NP

Teaching program

Lectures Principles: - Steady state study method - Transient state study methods Application example n° 1: Electronic components - Modeling and association of basic electronic components - Application to the instrumentation chain and the control of power semiconductor components Application example n° 2: Power electronics - Switching, conversion functions (course); - Different levels of study of a static converter Application example n° 3: Electrical networks - Electrical power, - Three-phase networks and Transformers Directed work Circuit simulation in transient state with Simulink Association of electronic components Study using MATLAB of the operation of a static converter Power calculation and transformer Practical work Implementation of an instrumentation amplifier Power measurement on a transformer

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

Objective

The objective is to train: - in the time and frequency analysis of signals and in the analysis of linear and translation-invariant systems. This course allows the introduction of basic signal processing tools. The typical application is the functional analysis of the instrumentation chain - in the modeling of physical systems using a graph representation allowing both a functional, structural (causal properties) and behavioral analysis (deduction of mathematical models: state equations) of the systems.

Skills acquired

Being able to manipulate classical mathematical models of signals and systems (transfer function, differential equation, impulse response, convolution, link graph, etc.), knowing how to solve a simple analog signal processing problem, knowing how to assign and analyze the causality of processes. 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 modeling engineering, analysis of continuous systems and signal processing.

Prerequisites

First and second order linear physical systems and linear differential equations

Assessment

We assess students' ability to manipulate theoretical models to answer a process behavior study and analyze signals. Through continuous assessment and the end-of-semester exam, we assess the ability to manipulate theoretical modeling tools. In practical work, we assess students' ability to understand a real system and compare the modeling to the real system.

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. CM10 to CM15 Analogies in linear systems: Maxwell and Darieus models, Bond-Graph theory / Structure, effort and flow / - Sources of effort and causal flow / Establishment of state equations from the bond graph / Bond graph-block diagram transition 6 1-hour tutorials 1. Convolutional system & Fourier transform 2: Template and synthesis of a filter 3: Modulation - Demodulation in the instrumentation chain 4: Study of the same system using different modeling tools: differential equation, convolution, transfer function 5: Modeling by bond graphs 6 Establishment of state equations from the bond graph 3 lab work: TP1 identification of 1st and 2nd order system, TP2 Study and analysis of filtering in electronic CAD TP3 Study of an instrumentation chain the dynamometer

Total hours : 40
Lecture hours : 20
Tutorials hours : 20
Practical/lab hours : 0

Objective

The EC aims to be a foundation course for the analysis of complex systems. This objective is achieved through the study of analytical methods of mechanics applied to systems with localized variables: mechanical, electrical and electromechanical.

Skills acquired

Modeling in electricity and mechanics of discrete systems comprising a finite but potentially large number of degrees of freedom; Consolidation (and amplification) of basic knowledge in this field.

Prerequisites

Newtonian point and solid mechanics; electric circuits based on linear dipoles; composition, derivation, integration in the Riemann sense; multivariate functions, partial derivatives; minimal knowledge of a scripting language (examples are illustrated by simulations in Maxima language).

Assessment

NF: final EC grade EE: final exam grade I1: grade for written questioning in session No. 1 I2: grade for written questioning in session No. 2 I3: grade for written questioning in session No. 3 NF = (9 x EE + i1 + i2 + i3) / 12

Teaching program

The program is structured around ten lessons: L1: The Euler-Lagrange and Hamilton methods are introduced for non-dissipative problems with 1 degree of freedom (dof); L2: they are extended to the case of 2 dofs, the Lagrange multiplier method is introduced; L3: and finally they are generalized to the case of any finite number of dofs; the related vocabulary is proposed. L4: These methods are applied to linear electrical circuit problems; L5: the circuit with non-linear self-inductance is then treated as a support for the notions of phase plane and quadrature. L6: The previous elements are then used to treat electromechanical problems. L7: The variational foundations of the methods are explained. L8: Systems with holonomic or non-holonomic connections are approached via the Ferrers and Lagrange multiplier methods. L9: Viscous and Joule dissipations are introduced using the Rayleigh dissipation function. L10: Some theoretical developments around the Hamilton-Jacobi equations conclude the discussion.

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

Objective

The objective of this EC is to acquire the theoretical bases of Discrete Mathematics (graphs, propositional logic, languages, automata, etc.) which constitute prerequisites for the training of engineers in Information and Communication Sciences and Technologies (optimization, scheduling, control, IT, etc.).

Skills acquired

At the end of this course, students will be able to: - model a discrete event system using language theory and finite state automata. - solve an optimization problem using graph theory - conduct and analyze/demonstrate reasoning using propositional logic.

Prerequisites

None

Assessment

Written (assessment of theoretical knowledge on the four parts of the EC program

Teaching program

The courses include 4 parts: - Graph theory: ordered structures (lattices, graphs and trees), directed and undirected graphs, paths and properties (chain, paths, cycle, circuits, Eulerian, Hamiltonian, Chinese), connectivity and decomposition, adjacency and incidence matrix, graph isomorphism, graph algorithms (shortest path, number of paths of length n, determination of flows, coloring, notion of complexity). - Boolean algebra: Boolean expression and functions, Lagrange normal forms, simplification laws, Karnaugh diagrams. - Discrete Event Systems: Introduction to the notion of state, Huffmann method, theory of languages and automata (words and languages, operations on languages, prefix closure, regular expressions, deterministic and non-deterministic automata, Kleene's theorem, synchronous product and composition, determination, controllability theorem, controllable supreme, synthesis of supervisors. - Propositional logic: proposition and logical formula, connectives, predicates and quantifiers, propositional equivalences, proof methods, first-order predicate logic, extensions and temporal logics

EC 5JESNN2	English	UE 5JUSNN02 Languages 1	C. Corringer

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

Objective

The aim of this course is to consolidate students' knowledge in the four language activities (written production, interactive oral production, written comprehension, oral comprehension), 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.

EC 5JESNN2	Modern languages 2	UE 5JUSNN02 Languages 1	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. 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

Having followed the language studied as 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. Having followed the language studied as 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 : 1
Tutorials hours : 0
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 •Interpret the basic concepts of macroeconomic, microeconomic and financial analysis •Carry out external and internal diagnoses of a company

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

EC 5JESNN1	**Electrical authorization and occupational health**	*UE 5JUSNN01 General Training 1*	*T. Boileau*

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

Objective

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

Skills acquired

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

Prerequisites

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

Assessment

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 5JESNN1	**Industrial conferences**	*UE 5JUSNN01 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-knowledge and knowledge 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.

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: 2 sessions Session 1: - presentation of the content of the project management courses as well as the expectations of the annual 1A project. - What is a project? - the complexity of a project (systemic vision) Session 2: - The project approach (V process; agile methods, project portfolio management) - Project and problem-solving approach - Presentation of the guide "Managing a project in a team" which will be the basis for 1A projects 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 5JESNN1	1st year project	UE 5JUSNN01 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 ISN_FISE

Semester S6

Code	Course Unit	ECTS	Code	Course	Coeff	Teacher	Vol	CM	TD	TP
			6JESNN51	Numerical Analysis	0,6	*?*	**36**	16	20	0
6JUSNN05	Mathematics 2	**5**	6JESNN50	Probability and statistics	0,4	*?*	**36**	18	18	0
			6JESNN60	Dynamics of Energy Systems & Applied Kinematics CATIA	0,44	*B. Remy*	**30**	10	8	12
6JUSNN06	Automation, thermodynamics and simulation	**5**	6JESNN61	Automatic - Dynamics and Control of Systems	0,56	*J. Daafouz*	**36**	14	7	15
6JUSNN04	Study office	**5**	6JESNN40	SAMI design office	1	*V. Louis-Dorr*	**45**	0	0	45
			6JESNN70	Algorithmics and Object-Oriented Programming	0,36	*V. Chevrier*	**30**	7	5	18
			6JESNN71	Databases	0,28	*?*	**18**	6	3	9
6JUSNN07	Computer science	**5**	6JESNN72	Algorithms and data structures	0,36	*YQ Song*	**27**	9	6	12
			6JESNN20	English	0,5	*C. Corringer*	**24**	0	24	0
			6JESNN21	Modern Languages 2	0,5	*A. Quesada*	**24**	0	24	0
6JUSNN02	Languages 2	**5**	6JESNN22	Validation of the French language clearance certificate	pass/fail	*A. Quesada*	**1**	1	0	0
			6JESNN12	Management	0,2	*F. Temsamani*	**16**	10	6	0
			6JESNN14	Innovation and Entrepreneurship	0,2	*F. Temsamani*	**12**	0	12	0
			6JESNN13	Electrical authorization and occupational health	pass/fail	*T. Boileau*	**0,5**	0	0	0,5
			6JESNN15	CSR 2	pass/fail	*C. Laurent*	**14**	8	6	0
			6JESNN16	Industrial conferences	pass/fail	*P. Villette*	**6**	6	0	0
			6JESNN11	Communication and professional integration	0,2	*A. Thimon*	**14**	2	12	0
6JUSNN01	General Training 2	**5**	6JESNN10	1st year project	0,4	*N. Marpeau*	**20**	0	0	20
	Projects (foreign students)	**25**		Projects (foreign students)	1	*S. Gallaire*				

Total hours : 36
Lecture hours : 16
Tutorials hours : 20
Practical/lab hours : 0

Objective

This course provides an introduction to the various techniques for numerically solving problems encountered in engineering science. Its objective is to provide numerical mathematical problem-solving techniques, the associated algorithms, and their computer implementation (in Matlab) for simulating 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 numerical method most suited to solving 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

Practical work grade: obtained from one or more practical work reports and/or a practical work exam. Written grade: written exam at the end of the semester. The EC grade = 0.4*Practical work+0.6*E.

Teaching program

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

EC 6JESNN5	Probability and statistics	UE 6JUSNN05 Mathematics 2	?

Total hours : 36
Lecture hours : 18
Tutorials hours : 18
Practical/lab hours : 0

Objective

Learn to manipulate random variables in order to model random problems (which can later be used in signal analysis, system safety, modeling component lifetimes, etc.).

Skills acquired

Model random phenomena. Calculate probabilities and expected values. Understand the concept of independent variables. Use the law of large numbers. Use the central limit theorem and the normal distribution (to calculate probabilities and construct a confidence interval). Model queues using Markov chains and Poisson processes.

Prerequisites

Integral calculus, series calculations

Assessment

Written exam and practical work report

Teaching program

Lectures: - Definitions of probability on finite, countable or continuous universes. - Notions of conditional probability, independence, and Bayes' theorem. - Real random variables and vectors and their distribution (discrete or density). - Distribution function and characteristic function. - Expectation, variance, covariance. - Law of large numbers, central limit theorem and application to confidence intervals. - Markov chains - Poisson processes - Queues tutorial: Exercises applying the course. Exercises chosen for their content close to the concerns of engineers and the industrial world. lab work: Modeling a random phenomenon such as a queue, or Markov chain, on Matlab.

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

Objective

This involves learning to model mechanical and energy systems based on the implementation of models derived from physical principles (conservation of momentum and conservation of energy), clearly identifying the input and output parameters of these systems and establishing input-output type relationships between these quantities.

Skills acquired

Know how to break down a mechanical system into simple elements, identify the types of connection and model this part on Computer Aided Design (CATIA) software. Know how to model the behavior of an energy system or one of its elements in static or dynamic mode.

Prerequisites

None

Assessment

Assessment on Machines for the Kinematics section, End of module test for the Thermodynamics section. Final grade = (lab work grade) * 1/2 + (Test) * 1/2

Teaching program

The 27-hour course is made up of two parts: - A mechanical part (Kinematics under CATIA) of 12 hours (3 x 4 = 12 hours of practical work under catia). - A thermodynamic part of 18 hours (7 x 2 hours of lectures and 2 x 2 = 4 hours of tutorials) 1. Mechanical Part: The lecture part will aim to review the different types of mechanical connections (Pivot, rotation, embedding, etc.) used to connect mechanical parts and to introduce the CATIA mechanical design software. The practical part will consist of putting into practice the concepts seen in class. Students will have to design a mechanical system under CATIA and study its kinematics. 2. Thermodynamics / Energy of systems section: The course section will aim to learn how to model complex energy systems by reviewing the different possible models: - Thermodynamic approach - Enthalpic methods or energy balances - Analytical or numerical models - Convolutional and parametric methods These different techniques will then be used in the context of two tutorials.

Total hours : 36
Lecture hours : 14
Tutorials hours : 7
Practical/lab hours : 15

Objective

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

Skills acquired

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

Prerequisites

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

Assessment

NF: final grade of the EC, EE: written exam, MT: Average of 3 tutorial tests, lab work: lab work grade NF = max ((3*EE + lab work)/4), (2*EE + MT + lab work)/4).

Teaching program

Lectures State representation of dynamic systems Controllability and observability properties. Criteria in the case of linear systems invariant by translation in time State feedback with observer. Separation theorem of eigenvalues Application to the single-input-single-output case Graphical methods for assessing stability and robustness: Nyquist criterion, stability margins Rejection of disturbances Role of classical regulators Frequency approach for the adjustment of regulators Practical work Modeling and control of a Segway robot Modeling and control of a helicopter Bibliography KJ Astrom and RM Murray, "Feedback systems: an introduction for scientists and engineers", Princeton University Press

Total hours : 45
Lecture hours : 0
Tutorials hours : 0
Practical/lab hours : 45

Objective

The objective of this course is to conduct the study of a system in the form of a partially autonomous design office. The chosen application is the control of a fleet of robots: traveling salesman problems traveling N points under the constraint of the smallest distance

Skills acquired

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

Prerequisites

Courses in automation, modeling, signals and systems, computer science

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 mathematical, automatic and computer parts Unit development Cross-validations (Math, Info, Auto) Mid-term review Prototyping Technical integration of processes Presentation Demonstration

EC 6JESNN7	Algorithmics and Object-Oriented Programming	UE 6JUSNN07 Computer science	V. Chevrier

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

Objective

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

Skills acquired

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

Prerequisites

Information representation, Algorithms and programming, Software tools.

Assessment

Assessment methods: continuous assessment and a final practical computer-based exam

Teaching program

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

EC 6JESNN7	Databases	UE 6JUSNN07 Computer science	?

Total hours : 18
Lecture hours : 6
Tutorials hours : 3
Practical/lab hours : 9

Objective

A large majority of IT systems (industrial or corporate) rely on database management systems for data storage and querying. This EC covers the design and operation of relational and NoSQL databases as well as their querying via connectors and their exploitation in a computer program.

Skills acquired

- Design a relational database - Implement and operate a relational or NoSQL database

Prerequisites

Algorithms and Programming 1A

Assessment

- Know how to design and operate a relational or NoSQL database (MongoDB) Assessment methods: continuous assessment (practical test), written exam

Teaching program

Lectures: - General introduction: Data, Databases and Database Management Systems (DBMS). - The Entity/Association model: Entities, associations (binary and generalized), attributes and identifiers. - The relational model: Definition of a relational schema. Transition from an E/A schema to a relational schema. - The SQL language: Simple queries, queries on several tables, nested queries. Aggregation. Update. - Introduction to NoSQL and MongoDB databases Tutorials: - Modeling a database, transition to the relational schema and normalization - Relational algebra and SQL queries Practical work: - Design and implementation of a database under MySQL and its query in SQL - Programming a Python application to query a database - Implementation and querying a MongoDB database

EC 6JESNN7	Algorithms and data structures	UE 6JUSNN07 Computer science	YQ Song

Total hours : 27
Lecture hours : 9
Tutorials hours : 6
Practical/lab hours : 12

Objective

- Advanced knowledge and techniques in programming, dynamic data structures and algorithm design. - Java development skills (use of the Java language as a course support).

Skills acquired

Autonomy in designing efficient algorithms and developing modular software. Mastery of object-oriented programming in Java.

Prerequisites

Knowledge of algorithms and object-oriented programming.

Assessment

Skills in algorithm design and use of dynamic data structures, as well as in Java programming are assessed by continuous assessment and a final practical test.

Teaching program

Courses: 1. Introduction to object-oriented programming in Java 2. Dynamic data structures (list, stack, queue, graph, tree, heap, dictionary and hash table) 3. Principle of algorithm design (Brute force, backtracking, ...) 4. Verification and unit testing Tutorials: Tutorial 1: Programming in Java (under Eclipse) Tutorial 2: Object-oriented programming in Java (under Eclipse) Tutorial 3: Linked list and graph (Dijkstra) Tutorial 4: Trees and heaps Tutorial 5: design of backtracking algorithms Tutorial 6: Unit testing (Junit) Practical work: Practical work 1: Object-oriented programming in Java (simulation of a distributor) Practical work 2: Graph and Dijkstra (bus routes) Practical work 3: Algorithms on Trees (management of a directory) Practical work 4: Backtracking (n queens problem)

EC 6JESNN2	English	UE 6JUSNN02 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.

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 : 1
Tutorials hours : 0
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 6JESNN1	Electrical authorization and occupational health	UE 6JUSNN01 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 6JESNN1	Industrial conferences	UE 6JUSNN01 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

EC 6JESNN1	Communication and professional integration	UE 6JUSNN01 General Training 2	A. Thimon

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 6JESNN1	1st year project	UE 6JUSNN01 General Training 2	N. 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, etc.) Presentation of all the 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

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
2, Avenue de la Forêt de Haye
54500 Vandoeuvre-lès-Nancy

Academic year 2025-2026
Detailed curriculum 2025-2026 ISN_FISE

Semester S7

Code	Course Unit	ECTS	Code	Course	Coeff	Teacher	Vol	CM	TD	TP
			7JESNN10	Modeling, control and evaluation of DES	0,64	*J.-F. Pétin*	**36**	12	8	16
7JUSNN01	Optimization / discrete event systems	**5**	7JESNN11	Static optimization	0,36	*P. Riedinger*	**18**	8	10	0
			7JESNN40	Nonlinear Systems and Robustness	0,5	*J. Daafouz*	**34**	20	6	8
			7JESNN41	Dynamic Optimization	0,25	*P. Riedinger*	**18**	8	10	0
7JUSNN04	Automation & Data Analysis	**5**	7JESNN42	Data analysis	0,25	*R. Ranta*	**16**	8	8	0
			7JESNN30	Software Analysis and Design	0,7	*H. Cirstea*	**40**	20	6	14
JUSNN03	Computer science	**5**	7JESNN31	Algorithms and complexity	0,3	*V. Chevrier*	**20**	10	10	0
			7JESNN21	Transmission of Information	0,5	*V. Louis-Dorr*	**36**	16	4	16
7JUSNN02	Signal and information processing	**5**	7JESNN20	Signal Processing	0,5	*D. Wolf*	**36**	20	12	4
			7JESNN60	Computer networks	0,5	*YQ Song*	**18**	6	2	10
7JUSNN06	Systems and networks	**5**	7JESNN61	System programming and C language	0,5	*?*	**18**	6	0	12
			7JESNN54	CSR 3	pass/fail	*B. Remy*	**14**	10	4	0
			7JESNN56	Industrial conferences	pass/fail	*P. Villette*	**6**	6	0	0
			7JESNN50	Communication and professional integration	0,15	*F. Temsamani*	**14**	6	8	0
			7JESNN51	Accounting Management	0,25	*J. Binet*	**18**	6	12	0
			7JESNN52	English	0,3	*C. Corringer*	**24**	0	24	0
7JUSNN05	General training 3	**5**	7JESNN53	Living Language 2	0,3	*A. Quesada*	**24**	0	24	0

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

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 Discrete Mathematics EC of 1A (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. - Grafcet: syntax and semantics elements, modeling, simulation and integration of a control system.

EC 7JESNN1	Static optimization	UE 7JUSNN01 Optimization / discrete event systems	P. Riedinger

Total hours : 18
Lecture hours : 8
Tutorials hours : 10
Practical/lab hours : 0

Objective

The objective is to provide and complete a basic culture in numerical optimization under constraints in support of the other courses of the diploma. Formulation and methods of numerical resolution of the main optimization problems of the engineer: least squares, quasi Newton, Simplex, quadratic programming, SQP, convex optimization, integer problem

Skills acquired

Knowledge of the necessary minimum conditions (KKT) under constraints. Formulation and translation of an optimization problem. Know how to operate in the choice of a numerical resolution method depending on the nature of the problem and its implementation.

Prerequisites

Mathematics at the 1st cycle level in science or preparatory classes for the major scientific schools. Differential calculus

Assessment

Written exam and platform report

Teaching program

Unconstrained optimization - Necessary and sufficient conditions of local minimum - Principle of descent methods and Convergence criterion - Descent procedure in a given direction - Algorithms: Gradient, Newton, Quasi-Newtonian (BFGS, DFP), Least squares: Gauss Newton and Levenberg Marquard, Conjugate gradients. Constrained optimization - Lagrange multipliers and Kuhn and Tucker conditions - Algorithms: - Linear programming - Quadratic programming (Eliminations and Lagrangian, active constraints) - Nonlinear programming (penalization method, SQP) Case of convex problems - Duality / Interior point algorithms Discrete case - Integer programming (Branch and Bound). Platform: Schumacher problem - Synthesis of a trajectory in minimum time of a mobile robot. Objective: Determine the trajectory and the control of a vehicle allowing the travel of a circuit in minimum time and without slipping. Translation of physical and dynamic constraints and numerical resolution

Total hours : 34
Lecture hours : 20
Tutorials hours : 6
Practical/lab hours : 8

Objective

The control of physical systems requires the consideration of nonlinearities and modeling uncertainties. The objective is to introduce the main nonlinear phenomena and to present the basic methods for the stability analysis of nonlinear systems. Methods for the synthesis of control laws for such systems are also presented. The concepts and tools necessary for the representation of uncertainties and their consideration in both the stability analysis phase and the control law synthesis phase are also addressed, with particular attention paid to methods based on convex optimization.

Skills acquired

Robustness analysis of a control loop, synthesis of control laws taking into account uncertainties, stability analysis and synthesis of control laws for nonlinear systems

Prerequisites

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

Assessment

NF: final grade of the EC, EE: written exam, lab work: lab work grade, NF = (2*EE + lab work)/3

Teaching program

Nonlinear phenomena Stability analysis: Lyapunov method and Lasalle invariance principle Nonlinear control laws Notions of uncertainty Representation of parametric uncertainties Notion of robustness in stability and performance Linear matrix inequalities and convex optimization Convex optimization-based approach for the synthesis of robust control laws Bibliography Hassan K. Khalil. “Nonlinear Systems”, Prentice Hall Kemin Zhou, John C. Doyle, “Essentials of Robust Control”, Prentice Hall. Daniel Alazard, Christelle Cumer, Pierre Apkarian, Michel Gauvrit and Gilles Ferreres. “Robustness and optimal control”, Cépadués-Editions, Toulouse

Total hours : 18
Lecture hours : 8
Tutorials hours : 10
Practical/lab hours : 0

Objective

The objective of this course is to present the two main principles (Bellman Principle and Minimum Principle) at the basis of the optimization of dynamic processes and systems. These principles are applied to decision problems (multiple allocations, investment plan, inventory management, etc.) but also to the optimal piloting and control of dynamic systems with some results commonly used in automation.

Skills acquired

Application of nonlinear programming to parametric optimization and identification problems. Application of dynamic programming to discrete-time decision and optimization problems. Synthesis of state feedback by optimizing a quadratic criterion (LQ regulator).

Prerequisites

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

Assessment

Written exam and platform report

Teaching program

Course: Nonlinear programming (NLP). Applications to parametric optimization and identification. Dynamic programming (Bellman principle). Applications to the search for optimal strategies (inventory management, multiple allocations, minimum weight path, etc.) and to the control of discrete-time systems. The minimum principle: Applications to LQ and minimum-time control of continuous-time dynamic systems. Platform: Optimal control of a Buck Boost power converter. Objective: Implementation of the "Forward Backward Sweep" algorithm on a problem of controlling a DC-DC converter by optimizing a quadratic criterion.

Total hours : 16
Lecture hours : 8
Tutorials hours : 8
Practical/lab hours : 0

Objective

Data analysis is a family of statistical methods whose main characteristics are that they are multidimensional and descriptive. Some methods, mostly geometric, help to highlight the relationships that may exist between different data and to extract statistical information that allows for a more succinct description of the main information contained in these data. Other techniques allow data to be grouped in such a way as to clearly reveal what makes them homogeneous, and thus to better understand them.

Skills acquired

Know how to extract important information from a dataset and interpret the results. Know how to classify data, either using supervised techniques when the information is available, or by highlighting natural separations between classes (clustering).

Prerequisites

Basic statistics, matrix calculus

Assessment

Grading of reports of tutorial sessions

Teaching program

Course - Introduction to factor analysis - Normalized principal component analysis - Supervised classification 1: linear and quadratic discriminant analysis - Supervised classification 2: large margin separators - Unsupervised classification, clustering (distances and aggregation methods, dendrogram, dynamic cloud methods, k-means) Tutorials based on Matlab - Normalized principal component analysis - Discriminant analysis (Fisher's iris) - Programming elementary functions and using the Matlab "Statistics" toolbox - Large margin separators (linearly separable data and soft margins)

EC 7JESNN3	Software Analysis and Design	UE JUSNN03 Computer science	H. Cirstea

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

Objective

Master best practices in object-oriented programming. Master the principles and tools of version control and build automation. Master unit testing techniques. Know other types of testing. Know the main software development models and their activities. Master object-oriented modeling methods, techniques, and languages (UML). Design object-oriented software by applying a set of software engineering principles and methods.

Skills acquired

Object-oriented analysis and design of an application. Implementation and testing in an object-oriented language. Versioning and automatic construction. Teamwork.

Prerequisites

Mastery of basic object-oriented programming techniques. Know how to use integrated programming environments.

Assessment

NF: final grade of the EC EE: written exam ETP: practical work exam NF = EE * 0.7 + ETP * 0.3

Teaching program

Review of the fundamental concepts of the object-oriented paradigm. Best practices for object-oriented programming (classes and interfaces, object creation, common methods, etc.). - Testing methodology and techniques; unit tests and stubs. - Continuous integration. Version control techniques and tools. Software build automation techniques and tools. - Introduction to the software development process: software development process models, software development process activities. Introduction to agile methods. - Use of diagrams (UML) in the development process. Interaction modeling (use case diagrams, sequence diagrams, communication diagrams). Behavioral modeling (activity diagrams, state diagrams). - Structural modeling (class diagrams, package diagrams, component diagrams, deployment diagrams).

EC 7JESNN3	**Algorithms and complexity**	*UE JUSNN03 Computer science*	*V. Chevrier*

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

Objective

• Objectives Understand algorithmic complexity and its major classes, Study efficient algorithms on prototypical problems, Study algorithm construction strategies Implement these concepts on prototypical examples

Skills acquired

Know how to recognize the major classes of complexity, Study efficient algorithms for prototypical problems (sorting, searching, etc.) Know and be able to apply algorithm construction strategies

Prerequisites

Algorithms and programming (object) 1A

Assessment

Written exam

Teaching program

The course is built around 5 algorithm construction strategies: greedy algorithms, divide and conquer, dynamic programming, brute force, and backtracking. The course is preceded by a personal reflection and reading assignment to introduce the problems addressed. It is followed by implementation exercises and individual personal work.

Total hours : 36
Lecture hours : 16
Tutorials hours : 4
Practical/lab hours : 16

Objective

Understand the fundamentals of information theory and their implementation in digital data transmission, in baseband, and transposed quadrature with x states xQAM. The modeling of transmission media is covered as well as the format and coding of data Quantity of information, entropy of a source, joint entropy of 2 sources, entropy of Markovian sources Source coding compression concepts, adaptation of the source to the channel

Skills acquired

Ability to understand the concepts and tools of digital data transmission across all physical layer media. It also addresses the concept of information measurement.

Prerequisites

1st year analog and digital electronics and 2nd year signal processing courses

Assessment

Assessment of skills, both theoretical and practical, on the ability to use transmission design and analysis tools and on the implementation of these tools.

Teaching program

CM1 to CM8 Quantity of information, entropy of a source, joint entropy of 2 sources, Markovian source entropy Source coding: coding technique, concepts of compression, adaptation of the source to the channel Channel coding: coding technique lecture 9 to CM18 Modeling of transmission media Nonlinear quantization Data format and coding Valence, Modulation speed, bit rate Power spectral density of digital transmissions Intersymbol interference, Nyquist filter, phase trajectory, x-state modulation xQAM, tutorial: Huffman coding Practical work lab work 1 Huffman coding lab work 2 Baseband transmission lab work 3 & 4 QAM 16 modulation in a radio transmission channel with noise: simulation and real application

EC 7JESNN2	Signal Processing	UE 7JUSNN02 Signal and information processing	D. Wolf

Total hours : 36
Lecture hours : 20
Tutorials hours : 12
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 tutorial report and 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

EC 7JESNN6	Computer networks	UE 7JUSNN06 Systems and networks	YQ Song

Total hours : 18
Lecture hours : 6
Tutorials hours : 2
Practical/lab hours : 10

Objective

This course presents the fundamental concepts of computer networks on which Internet technology is built: the OSI model, local area networks (e.g., Ethernet), Internet protocols (IP, ICMP, ARP DHCP, TCP, UDP, DNS), the principles of network interconnection with practice on network equipment: hub, switch and router. The implementation consists of installing switched and routed networks, as well as the development of communicating applications (client-server) via sockets in C language.

Skills acquired

Knowledge of the principles of how the Internet works - Know how to configure switches and routers and install a network - Know how to develop communicating applications using the client-server model

Prerequisites

Information theory, Transmission and coding of information, Algorithms and programming (C language)

Assessment

The skills acquired are assessed by a written exam concerning the fundamental concepts of networks on the one hand, and by an individual project on mastering the development of communication applications on the other hand.

Teaching program

Course: - OSI model, encapsulation, principle of error detection - MAC protocols (eg, ALOHA, CSMA, Ethernet) - Internet protocols (IP, ICMP, ARP, DHCP, DNS, TCP/UDP) - Network interconnection (Ethernet switching, IP routing) - Communicating client-server applications with socket (C language) Practical work: - Protocol analysis with Wireshark - Socket programming - IP routing - Ethernet switching

EC 7JESNN6	**System programming and C language**	*UE 7JUSNN06 Systems and networks*	*?*

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

Objective

The objective of this EC is to introduce the basics of programming in C language (primitive types, arrays, pointers and structures) and multi-tasking applications: threads, synchronization and semaphore management.

Skills acquired

- Implement C language programs and multi-threaded applications

Prerequisites

Algorithms and Programming 1A

Assessment

- Know how to implement a program in C language and with threads for a given problem Assessment methods: mini-project grade, written exam

Teaching program

Course: - C programming: language elements - Pointers and structures - Threads and semaphores Practical work: - First programs in C language - Programming the power of 4 project in C - Programming threads and semaphores Individual mini-project: programming in C of an advanced program and communication (in connection with the EC Computer Networks of S7)

EC 7JESNN5	CSR 3	UE 7JUSNN05 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 7JESNN5	**Industrial conferences**	*UE 7JUSNN05 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

EC 7JESNN5	Communication and professional integration	UE 7JUSNN05 General training 3	F. Temsamani

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

EC 7JESNN5	Accounting Management	UE 7JUSNN05 General training 3	J. Binet

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

EC 7JESNN5	**English**	*UE 7JUSNN05 General training 3*	*C. Corringer*

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

Objective

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

EC 7JESNN5	**Living Language 2**	*UE 7JUSNN05 General training 3*	*A. Quesada*

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 participate in 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

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

Academic year 2025-2026
Detailed curriculum 2025-2026 ISN_FISE

Semester S8

Code	Course Unit	ECTS	Code	Course	Coeff	Teacher	Vol	CM	TD	TP
			8JESNN10	English	0,25	*C. Corringer*	**24**	0	24	0
			8JESNN11	Modern Languages 2	0,25	*A. Quesada*	**24**	0	24	0
			8JESNN13	CSR	0,25	*F. Temsamani*	**14**	8	6	0
			8JESNN14	Industrial Conferences - Research Day	pass/fail	*B. Remy*	**12**	12	0	0
8JUSNN01	General Training 4	**6**	8JESNN12	Marketing Strategy & Business Simulation	0,25	*J.-C. Marpeau*	**21**	3	18	0
			?	Identification of Systems	?	*M.Giaccagli*	**18**	8	0	10
			?	SA Machine learning	?	*M.Kallas-Edelson*	**20**	10	10	0
?	8_SA1 AI and Machine Learning	**6**	?	Reinforcement learning	?	*J. Daafouz*	**22**	8	6	8
			?	Digital Control SA	?	*J. Kreiss*	**28**	10	8	10
			?	Predictive ordering	?	*P. Riedinger*	**16**	4	12	0
?	8_SA2 Control and optimization	**6**	?	Event order	?	*R. Postoyan*	**16**	6	2	8
			?	Digital Systems Design SA	?	*M.Kallas-Edelson*	**26**	6	4	16
			?	Computer vision design office	?	*S. Le Cam*	**22**	0	0	22
?	8_SA3 Embedded and distributed systems	**6**	?	IoT systems	?	*YQ Song*	**16**	5	2	9
			?	Safety of Operation SA	?	*N. Brinzei*	**40**	20	2	18
?	8_SA4 Safety, security	**6**	?	Security of Automated Systems	?	*?*	**16**	6	2	8
			8JESNN62	SLE Machine learning	0,5	*M.Kallas-Edelson*	**20**	10	10	0
8JUSNN06	8_SLE1 Preparatory	**6**	8JESNN61	Cybersecurity Awareness	0,5	*R. Badonnel*	**20**	12	4	4
			8JESNN70	SLE Digital Control	0,3334	*J. Daafouz*	**30**	10	8	12
			8JESNN71	SLE Digital Systems Design	0,3334	*M.Kallas-Edelson*	**30**	6	4	20
8JUSNN07	8_SLE2 Control and design of embedded and real-time systems	**9**	8KEJ0N57	Real-Time Systems	0,3334	*V. Bombardier*	**40**	8	16	16
			8JESNN80	SLE Operational Safety	0,3334	*N. Brinzei*	**40**	20	2	18
			8JESNN81	SLE System Engineering	0,3334	*E. Levrat*	**20**	8	12	0
8JUSNN08	8_SLE3 Systems Engineering and Safety	**9**	8KEJ0N58	Modeling, Verification and Experimentation of Systems	0,3334	*D. Mery*	**40**	20	20	0
	Projects (foreign students)	**25**		Projects (foreign students)	1	*S. Gallaire*				

EC 8JESNN1	English	UE 8JUSNN01 General Training 4	C. Corringer

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, the expressions necessary for guidance (signposting) -optimization of the content and the 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

• Objectives 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 Development of the ability to communicate and exchange. Self-confidence in a foreign language. Written and oral comprehension, written and oral production (continuous and interactive) in a foreign language. Knowing how to set objectives, learning to learn. • Prerequisites For non-beginners: have a B1 level. For beginners have an A2 level. • Teaching program lecture: 0h tutorial: 24h lab work: 0h 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,

EC 8JESNN1	**CSR**	*UE 8JUSNN01 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 8JESNN1 **Industrial Conferences - Research Day** *UE 8JUSNN01 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

EC 8JESNN1	Marketing Strategy & Business Simulation	UE 8JUSNN01 General Training 4	J.-C. Marpeau

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.

EC ?	**Identification of Systems**	*UE ? 8_SA1 AI and Machine Learning*	*M.Giaccagli*

Total hours : 18
Lecture hours : 8
Tutorials hours : 0
Practical/lab hours : 10

Objective

The control of dynamic systems requires a model whose identification is carried out from experimental measurements on the system in operation, generally subject to disturbances. The objective of this course is to introduce the concepts and tools necessary for mastering the basic techniques of identifying dynamic systems.

Skills acquired

Know how to identify a model from experimental data

Prerequisites

Mathematics and optimization courses, first- and second-year automation courses, and second-year signal processing courses

Assessment

Identification of a system on a computer from experimental measurements

Teaching program

Introduction: Definition and objectives of identification Model structures: Principle of parsimony, Identifiability Deterministic models and stochastic models Classical identification methods Graphical methods Least squares methods Instrumental variable methods Optimization-based methods Implementation and validation Choice of input signals Validation Bibliography T. Soderstrom and P. Stoica. System Identification. Prentice Hall, 1989. Y. Landau, Identification des systèmes, Editions Hermes, 1998

EC ?	SA Machine learning	UE ? 8_SA1 AI and Machine Learning	M.Kallas-Edelson

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

Objective

The EC is divided into 2 parts: On the one hand, the presentation of kernel methods. A particular focus will be made through the SVM (Support Vector Machine) classification method which is one of the most used. On the other hand, the introduction to neural networks from a perceptron to the multi-layer perceptron (Multi-Layer Perceptron MLP) and finishing with the convolutional neural network used for image classification.

Skills acquired

- Ability to manipulate large data sets and extract relevant information - Proficiency in implementing basic techniques - Ability to manipulate algorithms and parameterize them correctly - Ability to classify high-dimensional data

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 composed of: 30% the grade of the report on SVM 30% the grade of the report on NN 40% the grade of the tree leaf classification project

Teaching program

Kernel Methods and SVM 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 SVM Neural networks Lectures - Introduction to the perceptron, extension to the multi-layer perceptron with presentation of back propagation - Introduction to the convolutional neural network used in the case of image processing Practical work on a computer machine - Complete programming of the backpropagation algorithm and application to toy examples Mini-project The objective is to classify tree leaves

EC ?	Reinforcement learning	UE ? 8_SA1 AI and Machine Learning	J. Daafouz

Total hours : 22
Lecture hours : 8
Tutorials hours : 6
Practical/lab hours : 8

Objective

At the heart of artificial intelligence, reinforcement learning offers an approach to optimizing the behavior of general dynamic systems without requiring an explicit mathematical model. The objective of this course is to introduce the concepts of reinforcement learning, present the main associated methods and algorithms, and highlight the links with optimal control.

Skills acquired

Know how to pose a reinforcement learning problem and identify the differences with optimal control. Know the main algorithms and apply them in numerical simulation.

Prerequisites

This course requires basic knowledge acquired at ENSEM in the first and second years in dynamic systems theory, mathematics, and optimization. However, the necessary reminders will be provided.

Assessment

Written test and practical work report.

Teaching program

General introduction - Definition of an optimal control problem. - Dynamic programming: Bellman principle, Bellman equation, Exact and approximate solutions, Curse of dimension. - Basics of reinforcement learning Definition and objectives Reward-based systems. Main components: states, actions, rewards, policies. Environment and agent. - Reinforcement learning methods Exploration/exploitation balance. Main algorithms: Value-based methods: Q-learning, SARSA. Policy-based methods: Policy Gradient. Actor-critic approaches. - Link between optimal control and reinforcement learning Tutorials (tutorial) and practical work (lab work) will be offered throughout the course to train students to apply the concepts and techniques studied

EC ?	**Digital Control SA**	*UE ? 8_SA2 Control and optimization*	*J. Kreiss*

Total hours : 28
Lecture hours : 10
Tutorials hours : 8
Practical/lab hours : 10

Objective

This course is dedicated to the modeling, analysis and control of discrete-time dynamic systems. The objective is to introduce the basic concepts and techniques of synthesizing numerical control laws and to understand the challenges related to numerical implementation. Emphasis is placed on the state-space approach and modern methodologies for designing numerical control laws. The concepts introduced will be illustrated with academic examples in tutorials and implemented on a Lego robot in simulation followed by experimental validation.

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, mathematics for engineers, basic concepts of signal processing (sampling, z-transform).

Assessment

Written exam and long practical work on implementing a digital control

Teaching program

Contents: - Introduction: issues related to numerical control - Modeling and representation of discrete-time systems and sampled systems - Stability analysis and structural properties - Synthesis of discrete-time correctors: emulation, direct synthesis, polynomial approach. - Implementation aspects of numerical control. References: K.J. Astrom, B. Wittenmark, Computer-Controlled Systems: Theory and Design, Prentice Hall. Katsuhiko Ogata, Discrete-time control systems, Prentice Hall.

EC ?	Predictive ordering	UE ? 8_SA2 Control and optimization	P. Riedinger

Total hours : 16
Lecture hours : 4
Tutorials hours : 12
Practical/lab hours : 0

Objective

This course provides an introduction to predictive control for discrete-time linear systems. The main associated concepts are presented and their implementation illustrated with examples. Advantages and disadvantages are discussed, particularly with regard to the consideration of constraints, the feasibility and stability of the approach, and the induced numerical costs.

Skills acquired

Knowledge of advanced control and optimization techniques, synthesis of a Kalman filter Implementation in the case of convex constraints and quadratic cost

Prerequisites

Courses Optimization 1A, Automatic 1A and Numerical Control 2A

Assessment

Practical work report

Teaching program

Course Problem Formulation - convex optimal control - finite horizon approximation - model predictive control MPC Problem Setup and Parameters Optimization Problem How to get Integral Action Numerical Example – The Drone Regulation Problem MPC Closed-loop Properties Terminal Components - Constraints Satisfaction and stability tutorial-lab work machine: - supply chain management, predictive control for controlling the longitudinal movement of an aircraft in cruise flight

EC ?	Event order	UE ? 8_SA2 Control and optimization	R. Postoyan

Total hours : 16
Lecture hours : 6
Tutorials hours : 2
Practical/lab hours : 8

Objective

Event-driven control consists of updating system inputs only when necessary to meet the specifications, rather than at fixed time intervals as in classic periodic sampling schemes. This strategy makes it possible to significantly reduce the use of resources (such as network bandwidth or computing power), while maintaining stability or performance guarantees. The objective of this EC is to discover this field and to familiarize oneself with the main existing techniques, in particular via a practical exercise on the distributed control of a fleet of autonomous cars.

Skills acquired

Understand the motivations and challenges associated with using event-driven control. - Know how to mathematically model a system subject to an event-driven control law. - Know and apply the main event-driven control techniques. - Be able to simulate an event-driven control law using Matlab/Simulink.

Prerequisites

Linear automatic

Assessment

1-hour exam Practical work report

Teaching program

Lectures: 1. Introduction 2. Modeling 3. Sampling laws 4. Inter-transmission time: what guarantees? 5. Control by output feedback 6. Robust control 7. Experimental validation 8. Conclusion tutorial: familiarization with the relative threshold technique lab work: distributed control of a vehicle fleet in an event-driven manner

EC ?	Digital Systems Design SA	UE ? 8_SA3 Embedded and distributed systems	M.Kallas-Edelson

Total hours : 26
Lecture hours : 6
Tutorials hours : 4
Practical/lab hours : 16

Objective

To give students mastery of digital system design tools and the means to design medium complexity circuits (a few thousand logic gates) on configurable circuits (FPGA)

Skills acquired

Students gain skills in modeling digital integration systems on reconfigurable FPGA targets. The expertise is in the field of digital system design, whether combinatorial or sequential, and in rapid prototyping.

Prerequisites

Machine architecture, coding of digital numbers

Assessment

The final grade is made up of: 50% of the average of the 4 grades of the practical work 50% of the grade of the partial with a written exam of 1h30

Teaching program

Lectures Classification of integration targets: programmed and wired solutions. From specifications to design, reminders of Boolean Algebra Logic simulation. VHDL modeling Design and equation of combinational and sequential systems up to the finite state machine Tutorials Boolean Algebra, Coding, Realization of a parity bit generator High beam ignition control, synchronous counter, shift register Practical work Getting started with Quartus software, declaration of a project and graphic description. Functional and temporal analyses. Implementation on the hardware target VHDL description of combinational solutions then wiring of FPGA target, functional and temporal analyses code coverage: the 4-bit adder. Study of a professional simulator (MODELSIM): use of a test program (testbench). VHDL description of sequential solutions then FPGA target wiring, functional and timing analyses code coverage: clocks, counters

EC ?	**Computer vision design office**	*UE ? 8_SA3 Embedded and distributed systems*	*S. Le Cam*

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

Objective

The objective of this design office is to apply project-based learning to design, develop and experiment with a digital solution. It also allows students to learn project management through practice, develop autonomy and apply the S5, S6 and S7 courses through practice. It is dedicated to the development of a computer vision application for the detection and recognition of road signs in 2D images and video streams.

Skills acquired

Know and apply certain techniques of computer vision and recognition of objects in images - Implement an application for detection and recognition of objects

Prerequisites

Programming and algorithms, Matlab programming, object-oriented programming, software analysis and design, data structures, machine learning methods

Assessment

- Know how to apply image processing and machine learning techniques for object detection and recognition Assessment methods: project score

Teaching program

- Definition of the solution specifications - Image processing techniques using OpenCV and Matlab: Image filtering and denoising, Segmentation and thresholding (colors), Edge detection (Canny filter), Feature extraction for shape recognition, Template matching algorithms (SIFT, ORB) - Software development of the solution: Image acquisition, Object detection, Object recognition - Unit and integration testing - Validation and evaluation of the solution: accuracy rate - Demonstration of the solution

EC ?	**IoT systems**	*UE ? 8_SA3 Embedded and distributed systems*	*YQ Song*

Total hours : 16
Lecture hours : 5
Tutorials hours : 2
Practical/lab hours : 9

Objective

The Internet of Things (IoT) and wireless sensor networks represent a significant evolution of the Internet towards distributed cyber-physical systems. This course aims to introduce the IoT ecosystem by focusing on both data transmission protocols on the sensor network side and data distribution in the cloud.

Skills acquired

Understand the concepts of low-power protocols. Know how to develop IoT applications to collect and transmit sensor data and distribute it over the Internet/Cloud.

Prerequisites

Computer Networks Programming in Python

Assessment

The skills acquired in developing IoT applications will be assessed through practice (practical notes).

Teaching program

lecture: IoT Eco-systems: embedded platforms, transmission protocols for sensor networks (e.g. WiFi, IEEE802.15.4, Zigbee, LoRa), publisher/subscriber data distribution model (MQTT), data visualization and processing. tutorial: Sensor network simulation. lab work: - Short-range networks (XBEE) - Long-range networks (LoRa) - Sensor data distribution and processing (MQTT, Node-Red)

EC ?	Safety of Operation SA	UE ? 8_SA4 Safety, security	N. Brinzei

Total hours : 40
Lecture hours : 20
Tutorials hours : 2
Practical/lab hours : 18

Objective

Digital systems used to control or improve the performance of industrial 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 and their components 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

- Probabilities & statistics (S6) - Modeling of Discrete Event Systems (S7)

Assessment

examination to assess the level of theoretical knowledge of approaches to modeling and assessing the operational safety of systems, to assess the implementation of these approaches - continuous assessment in tutorial and lab work to assess the ability to model, assess and analyze the operational safety of critical industrial systems

Teaching program

Lectures: • Concepts and definitions: reliability, availability, maintainability, safety (RAMS), MTTF, MTBF, MTTR • Component reliability • Qualitative approaches for risk analysis: APR, AMDEC, HAZOP • Combinatorial approaches for modeling and evaluating the SdF of systems: - reliability block diagrams (RBD) - fault trees (AdD) • State-transition approaches for modeling and evaluating the SdF of systems: - analytical approaches: Markov chains (CoM), stochastic Petri nets (RdPS) - simulation approaches: Stochastic Activity Networks (SAN) • Functional safety: study and analysis of Safety Instrumented Systems (SIS) in accordance with current norms and standards (IEC 61508); Safety Integrity Levels (SIL) Tutorials: • Modeling of systems by SAN Practical work: • Modeling and probabilistic evaluation of binary and non-repairable systems by RBD and AdD (GRIF software) • Modeling and probabilistic evaluation of repairable/reconfigurable multi-state systems by CdM and RdPS (GRIF software) • Modeling and evaluation of the SIL level of SIS (GRIF software)

EC ?	Security of Automated Systems	UE ? 8_SA4 Safety, security	?

Total hours : 16
Lecture hours : 6
Tutorials hours : 2
Practical/lab hours : 8

Objective

Autonomous and 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 autonomous and 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

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: attacks and threats - Protection system: intrusion detection, firewall Tutorials: - Study of cryptographic systems Practical work: - Role-play with an industrial application case (ENSEM Cyber suitcase platform) to identify and remedy attacks on the control of an industrial and automated system (SCADA and control automation systems)

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

Objective

The EC is divided into 2 parts: On the one hand, the presentation of kernel methods. A particular focus will be made through the SVM (Support Vector Machine) classification method which is one of the most used. On the other hand, the introduction to neural networks from a perceptron to the multi-layer perceptron (Multi-Layer Perceptron MLP) and finishing with the convolutional neural network used for image classification.

Skills acquired

- Ability to manipulate large data sets and extract relevant information - Proficiency in implementing basic techniques - Ability to manipulate algorithms and parameterize them correctly - Ability to classify high-dimensional data

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 composed of: 30% the grade of the report on SVM 30% the grade of the report on NN 40% the grade of the tree leaf classification project

Teaching program

Kernel Methods and SVM 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 SVM Neural networks Lectures - Introduction to the perceptron, extension to the multi-layer perceptron with presentation of back propagation - Introduction to the convolutional neural network used in the case of image processing Practical work on a computer machine - Complete programming of the backpropagation algorithm and application to toy examples Mini-project The objective is to classify tree leaves

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

Objective

This module raises awareness and introduces students to the issues and problems related to cybersecurity (see CyberEdu label)

Skills acquired

Understand the motivations and need for IS security, Know the basic definitions and typology of threats, Understand and adopt the basic rules for organizations and individuals, Understand the vulnerabilities inherent in commonly used network and application mechanisms, Know the panorama of technical security solutions, Understand the methods and standards for taking security into account in a global and unitary way, Understand and anticipate the difficulties in security management, Present the cybersecurity business sectors.

Prerequisites

None

Assessment

Final exam

Teaching program

• Basic notions of cyber-security, • IT hygiene rules, • Network and system aspects related to cyber-security, • Operational management of cyber-security within an organization

EC 8JESNN7	SLE Digital Control	UE 8JUSNN07 8_SLE2 Control and design of embedded and real-time systems	J. Daafouz

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

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

Missing information

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 : 30
Lecture hours : 6
Tutorials hours : 4
Practical/lab hours : 20

Objective

To give students mastery of digital system design tools and the means to design medium complexity circuits (a few thousand logic gates) on configurable circuits (FPGA)

Skills acquired

Students gain skills in modeling digital integration systems on reconfigurable FPGA targets. The expertise is in the field of digital system design, whether combinatorial or sequential, and in rapid prototyping.

Prerequisites

Machine architecture, coding of digital numbers

Assessment

The final grade is made up of: 50% of the average of the 5 grades of the practical work 50% of the grade of the partial with a written exam of 1h30

Teaching program

Lectures Classification of integration targets: programmed and wired solutions. From specifications to design, reminders of Boolean Algebra Logic simulation. VHDL modeling Design and equation of combinational and sequential systems up to the finite state machine Tutorials Boolean Algebra, Coding, Realization of a parity bit generator High beam ignition control, synchronous counter, shift register Practical work Getting started with Quartus software, declaration of a project and graphic description. Functional and temporal analyses. Implementation on the hardware target VHDL description of combinational solutions then wiring of FPGA target, functional and temporal analyses code coverage: the 4-bit adder. Study of a professional simulator (MODELSIM): use of a test program (testbench). VHDL description of sequential solutions then FPGA target wiring, functional and timing analyses code coverage: clocks, counters Critical path and calculation of the minimum time required, Finite state machine and its VHDL code

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

Objective

This module is designed to deepen students' knowledge of the concepts, methods, models and tools for implementing real-time systems, taking into account the reactivity and determinism constraints of these systems. The objective is to learn how to implement an embedded system on the main embedded or real-time executives in the industry.

Skills acquired

• Use a methodology for designing real-time applications • Describe and analyze real-time scheduling mechanisms • Know the methodologies, models and tools used for designing real-time or non-real-time embedded applications (scepter model, real-time scheduling mechanisms, multi-tasking, cross-compilation, emulation).

Prerequisites

RSA System Part

Assessment

- Know how to analyze a real-time schedule - Know how to implement an embedded application with a real-time kernel 1 final exam + Project/lab work Note

Teaching program

• Methodology and models used for the design of TR applications (Sceptre Model). • Real-Time Scheduling Mechanisms (Rate Monotonic, Earliest Deadline First, Least Laxity First). • Notion of periodic and aperiodic tasks, independent or not (Deferred Servers, Sporadic Servers). • Management of shared resources (Mutual Exclusion, Synchronization, Communication). • Implementation of a real-time application on a target (ESP32) running with a FreeRTOS real-time kernel. • Management of I/O, UART, I²C, SPI, PWM, ADC/DAC (Temperature, CO_2, ultrasound sensors, etc.).

Total hours : 40
Lecture hours : 20
Tutorials hours : 2
Practical/lab hours : 18

Objective

Digital systems used to control or improve the performance of industrial 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 and their components 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

- Probabilities & statistics (S6) - Modeling of Discrete Event Systems (S7)

Assessment

examination to assess the level of theoretical knowledge of approaches to modeling and assessing the operational safety of systems, to assess the implementation of these approaches - continuous assessment in tutorial and lab work to assess the ability to model, assess and analyze the operational safety of critical industrial systems

Teaching program

Lectures: • Concepts and definitions: reliability, availability, maintainability, safety (RAMS), MTTF, MTBF, MTTR • Component reliability • Qualitative approaches for risk analysis: APR, AMDEC, HAZOP • Combinatorial approaches for modeling and evaluating the SdF of systems: - reliability block diagrams (RBD) - fault trees (AdD) • State-transition approaches for modeling and evaluating the SdF of systems: - analytical approaches: Markov chains (CoM), stochastic Petri nets (RdPS) - simulation approaches: Stochastic Activity Networks (SAN) • Functional safety: study and analysis of Safety Instrumented Systems (SIS) in accordance with current norms and standards (IEC 61508); Safety Integrity Levels (SIL) Tutorials: • Modeling of systems by SAN Practical work: • Modeling and probabilistic evaluation of binary and non-repairable systems by RBD and AdD (GRIF software) • Modeling and probabilistic evaluation of repairable/reconfigurable multi-state systems by CdM and RdPS (GRIF software) • Modeling and evaluation of the SIL level of SIS (GRIF software)

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

Objective

Introduce students to best practices in systems engineering with the aim of applying them through the projects and case studies offered throughout the training.

Skills acquired

Ability to analyze stakeholder requirements to determine system requirements, to define the functional, organic and behavioral architectures of a system.

Prerequisites

Object-oriented modeling (UML)

Assessment

Written exam and case study

Teaching program

Introduction to systems thinking and systems engineering Systems engineering guided by ISO/IEC 15288: - technical processes (requirements definition, requirements analysis, design of functional and organic architectures, etc.) - project processes (steering, decision-making, information management, definition of engineering tasks) - iterative and collaborative modeling process in systems engineering (best specification practices, black/white box visions, problem/solution description/prescription, etc.). Model-based systems engineering MBSE - Object-oriented approach based on the SysML modeling language: requirements and use case diagrams, structural diagrams (block, parametric), behavioral diagrams (activity, sequences, statecharts) - Executable specification, IBM Rhapsody specification and simulation environment

Total hours : 40
Lecture hours : 20
Tutorials hours : 20
Practical/lab hours : 0

Objective

The design of software-intensive systems requires the guarantee of safety and security properties, and design methods must be enhanced with verification and validation techniques to make them truly formal, tool-based methods. The module aims to deepen the concepts of programming and to study validation, verification, and modeling techniques using tools.

Skills acquired

• Master verification techniques and associated concepts • Use a model-checker, a semantic analysis tool and a testing tool • Recognize computable functions and decidable or undecidable problems • Master the principles of software safety • Explain and implement fixed-point theory • Know the basics of abstract interpretation

Prerequisites

None

Assessment

The assessment includes two written papers e1 and e2 and one practical work marked tpn. The final grade is calculated by applying the following weighted average: 0.4*e1+0.4*e2+0.2*tpn.

Teaching program

It aims to raise students' awareness of the need to clearly define requirements, the domain of the problem studied and to master the tools implementing formal methods for software and system safety. • Modeling and verification of systems for safety properties and contracts. • Temporal and time-delayed properties of systems. • Fixed point theory and applications. • Abstract interpretation. • Experimentation with analysis tools and techniques: model checkers, proof assistants, program analysis.

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
2, Avenue de la Forêt de Haye
54500 Vandoeuvre-lès-Nancy

Academic year 2025-2026
Detailed curriculum 2025-2026 ISN_FISE

Semester S9

Code	Course Unit	ECTS	Code	Course	Coeff	Teacher	Vol	CM	TD	TP
			9KEFGN61	Bank English	0,5	*C. Corringer*	**24**	0	24	0
			9KEFGN64	Professional integration	0,5	*F. Temsamani*	**30**	15	15	0
			9KEFGN66	Industrial conferences	pass/fail	*V. Chevrier*	**20**	20	0	0
9KUFGN14	General Training 5	**5**		Validation of international experience	pass/fail	*S. Gallaire*				
9KUISN09	Project	**5**	9KEISN92	Academic R&D Project - Industrial R&D Project	1	*N. Brinzei*	**60**	0	0	60
			9KEISN93	Basis of image processing	0,35	*D. Wolf*	**20**	16	4	0
			9KEISN33	Signal detection, extraction and reconstruction	0,35	*R. Ranta*	**20**	12	0	8
9KUISN12	S9 - SA - 01 Signal and image	**4**	9KEISN22	Biomedical Signals and Systems	0,3	*D. Wolf*	**16**	16	0	0
			9KEISN11	Aero Application	0,3333	*M.Jungers*	**16**	4	0	12
			9KEISDN61	Autonomous Flight of a Drone	0,3333	*P. Riedinger*	**16**	8	8	0
9KUISN11	S9 - SA - 02 Control and piloting	**4**	9KEISN14	Multi-Agent Systems Management	0,3333	*C. Morarescu*	**16**	8	8	0
			9KEISN32	Monitoring and Diagnosis	0,3333	*S. Maza*	**16**	12	4	0
			9KEISN31	Formal verification of automated systems	0,3333	*J.-F. Pétin*	**16**	2	2	12
9KUISN13	S9 - SA - 03 Safety and security	**4**	9KEISN34	Security of Automated Systems	0,3333	*? / J. Daafouz*	**16**	6	2	8
			9KEISN43	Distributed Algorithms and Blockchain	0,3333	*?*	**16**	6	2	8
			9KEISN44	Distributed Systems	0,3333	*V. Chevrier*	**16**	8	2	6
9KUISN14	S9 - SA - 04 Distributed systems	**4**	9KEISN45	IoT systems	0,3333	*YQ Song*	**16**	5	2	9
			9KEISN52	Introduction to Robotics	0,3	*D. Wolf*	**16**	8	0	4
9KUISN15	S9 - SA - 05 Robotics and Autonomous Vehicles	**4**	9KEISN53	Autonomous Vehicle Design Office	0,7	*? / J. Kreiss*	**28**	0	0	28
			9KEJ0N54	Mobile Applications and Internet of Things	0,3333	*T. Cholez*	**24**	6	10	8
			9KEISN73	Industrial embedded networks	0,3333	*YQ Song*	**20**	8	4	8
9KUISN17	S9 - SLE - 01 Intelligent communicating systems and security	**6**	9KEISN74	Security of an embedded system	0,3333	*?*	**20**	8	0	12
			9KEISN82	Distributed and distributed systems - Edge-Fog computing	0,25	*?*	**20**	6	2	12
			9KEJ0N56	Parallel and distributed programming	0,25	*S. Lefebvre / J. Martinez*	**22**	6	16	0
9KUISN18	S9 - SLE - 02 Advanced Machine Architecture	**8**	9KEJ0N55	Design and development of a system on a chip	0,5	*Y. Berviller / S. Lefebvre*	**70**	4	2	64
			9KEISN95	Image Processing	0,33	*S. Le Cam*	**20**	8	8	4
9KUISN19	S9 - SLE - 03 Advanced technologies for embedded systems	**6**	9KEISN96	Urbanloop design office	0,6667	*? / V. Bombardier*	**20**	10		10
	Projects (foreign students)	**25**		Projects (foreign students)	1	*S. Gallaire*				

EC 9KEFGN6	Bank English	UE 9KUFGN14 General Training 5	C. Corringer

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

Objective

This EC consists of two professionally oriented modules: Interacting Professionally and Scientific Communication. The objective of the EC is to give students skills in business English and scientific English. 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 international 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 to enable them to fill the identified gaps. The teacher helps students with their work, provides guidance, and answers their questions. Regular exercises and tests allow students to structure and assess their progress.

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	Industrial conferences	UE 9KUFGN14 General Training 5	V. Chevrier

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

Objective

Understand the reality of the engineering profession and know how to project the knowledge acquired in training into a professional framework.

Skills acquired

Knowledge of the company and more generally of the world of work (business, R&D, etc.) through real cases and testimonials.

Prerequisites

Engineering training

Assessment

Continuous Assessment - Participation in Conferences

Teaching program

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

EC	Validation of international experience	UE 9KUFGN14 General Training 5	S. Gallaire

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

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

Role-playing in the management of a large-scale engineering project. • Prerequisites

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

EC 9KEISN93	Basis of image processing	UE 9KUISN12 S9 - SA - 01 Signal and image	D. Wolf

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

Objective

The techniques used to extract useful information from an image often rely on specific mathematical tools and approaches specific to the discipline. This module aims to present the most interesting theoretical means and methodologies for processing and analyzing an image.

Skills acquired

Know how to handle a simple image analysis and processing problem from data acquisition to feature extraction

Prerequisites

ENSEM Signal Processing Course

Assessment

2-hour exam

Teaching program

Image sensors and vision systems Principles and devices for image formation (different types of cameras) Vision system: general and specialized architectures Point processing Logical or arithmetic processing Transfer functions Statistical analysis – thresholding Digital filtering of images Study of continuous and discrete 2D signals Linear spatial approach: discrete 2D convolution operation Frequency approach: discrete 2D Fourier transform Digital linear filtering of images, synthesis of 2D IIR and FIR filters Non-linear filtering Segmentation Introduction to image segmentation Notion of image primitives: contours, regions, geometric primitives, etc. Image thresholding techniques: methods based on histogram analysis Mathematical morphology The foundations of mathematical morphology Elementary transformations Set and functional definitions, mathematical properties The four elementary operators: erosion, dilation, opening, closing Grayscale morphology: "top hat" transform TCHF Notions of granulometry Morphological filters: sequential alternating filters Notions of skeleton: definition, properties, methods Watershed line, application to segmentation Geodesic transformations: definitions, properties, new operators, geodesic measurements

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

Objective

This module aims to present the most suitable theoretical tools and methodologies for efficiently detecting and analyzing non-stationary and/or multidimensional signals in noisy environments. The first part of the course focuses on detection theory. Classical detection methods will be presented, as well as performance measures for evaluating these detectors. In a second part, signal extraction and reconstruction tools will be discussed. Here, we will rely on decomposition and partial reconstruction techniques using different dictionaries, derived from physical models or estimated from data.

Skills acquired

Know how to detect and extract relevant information from a signal or collection of signals, after having identified the method(s) best suited to the problem posed; know how to evaluate the results.

Prerequisites

Basic knowledge of signal processing, linear algebra, probability and statistics; basics of Matlab

Assessment

Practical work report

Teaching program

Detection: Bayesian detection, risk curve MiniMax and Neyman-Pearson detectors Performance measurement, ROC curve Application to jump detection (Page-Hinkley) - Generic decompositions Short-term Fourier / spectrogram, Orthogonal wavelets, Mallat scheme, Denoising and Compression by partial reconstruction - Decompositions on pre-established dictionaries Redundant dictionaries and regression Sparse reconstruction, iterative regression - Decompositions on bases derived from data PCA reminders, whitening Source separation elements

EC 9KEISN22	Biomedical Signals and Systems	UE 9KUISN12 S9 - SA - 01 Signal and image	D. Wolf

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

Objective

The rapid development of signal and image processing techniques has brought about a true revolution in medical diagnostics and treatments. Since signals have become digital, the concept of a medical signal has evolved significantly. This module will present the most recent techniques and the specificities of biomedical signals and systems. The issues and main methodologies used in the processing of signals from nuclear medicine, radiodiagnosis, radiotherapy, chemodiagnosis, and chemotherapy will be developed.

Skills acquired

The knowledge acquired on the physical principles used to capture a medical signal or image combined with specific computational processing will enable students to address biomedical engineering problems, thus offering them the opportunity to access R&D jobs in this sector.

Prerequisites

ENSEM Signal Processing Course

Assessment

2-hour exam

Teaching program

Specific issues of biomedical signals and systems Medical instrumentation, processing machines Physiological signal processing Control command of biomedical systems Image sources in GBM US, X, nuclear tracer, scanner, DRR, etc. Processing of medical images Analysis of image quality Segmentation and quantification of attributes Multimodal analysis and image fusion The most recent advances Diagnosis: nuclear imaging and in particular multimodal, ECG, radiodiagnostics, photodiagnostics, PET Dosimetry: intensity modulation in radiotherapy, PDT

Total hours : 16
Lecture hours : 4
Tutorials hours : 0
Practical/lab hours : 12

Objective

The objective is to lead students to pose a realistic control problem inspired by the aeronautical field and to solve it using the concepts of control and multivariable optimization introduced in class. In this module, they will be confronted with specifications that go beyond the academic framework and they will have to take into account the real constraints encountered during the synthesis of an autopilot for an aircraft in the landing phase (nonlinearities, disturbances, delays, engine failure, multiple time scales, etc.).

Skills acquired

Know how to break down a complex control problem into several problems of reasonable size and complexity for the synthesis of a control law.

Prerequisites

First and second year automation courses.

Assessment

Full report on the problem of piloting an aircraft during landing phase provided at the end of the module

Teaching program

Concepts of multivariable control. - Nonlinear systems and decoupling - Synthesis of correctors by dynamic output feedback - Modeling of a civil aircraft during landing - Decomposition of longitudinal movement and lateral movement - Taking into account uncertainties and the flight envelope - Synthesis of correctors for each movement - Validation of these correctors on the nonlinear model of the aircraft - Evaluation of the autopilot obtained according to several scenarios and in the context of the descent from Frankfurt airport.

EC 9KEISDN	Autonomous Flight of a Drone	UE 9KUISN11 S9 - SA - 02 Control and piloting	P. Riedinger

Total hours : 16
Lecture hours : 8
Tutorials hours : 8
Practical/lab hours : 0

Objective

In the form of a design office, the objective of this module in advanced control is to achieve the design and development in simulation of a flatness-based control for the trajectory tracking of a "Crazyflie" drone. Deliverable: A simulator + summary report. This work is preparatory to an implementation on a model of the "drone" platform.

Skills acquired

Synthesis of a trajectory tracking control based on "flatness" and stabilizing output loop on a nonlinear system. Trajectory planning.

Prerequisites

1A and 2A automatic control courses. Dynamic Optimization courses.

Assessment

Report note + simulator.

Teaching program

Based on scientific articles, study of a model of a quadcopter and identification of the parameters. Presentation of the concept of flatness and verification of the flatness property on the drone model. Canonical form of controllability Synthesis of a state feedback on the tracking error with integral effect. Addition of an observer Generation of reference trajectories Simulation on Matlab-Simulink

Total hours : 16
Lecture hours : 8
Tutorials hours : 8
Practical/lab hours : 0

Objective

A multi-agent system is composed of a set of systems interacting according to certain rules. The dynamics of such a system includes continuous and discrete behaviors, so it is the study of a class of hybrid systems. One objective of this module is to exploit the topological properties of the interaction graph between agents in order to give easy-to-verify algebraic conditions for global agreement. We will also be interested in the problem of conditions guaranteeing a convergence speed at least equal to an initially planned speed. The targeted applications concern the cooperative control of vehicles/robots.

Skills acquired

Model a set of autonomous systems communicating with each other. Deduce the properties that ensure the controllability of this set. Implement a decentralized control strategy.

Prerequisites

Courses: Mathematics 1A, Automatics 1A 2A, Graph Theory.

Assessment

Work to be submitted or presented orally.

Teaching program

This module has four parts: Algebraic graph theory; Spectral graph theory; Consensus protocols; Applications. The applications part is divided into several sections: Oscillator synchronization; Rendezvous problem; Decentralized formation control; Flocking (speed alignment); Community detection in a network.

Total hours : 16
Lecture hours : 12
Tutorials hours : 4
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)

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

The final assessment will be based on a graded report (on the continuous part) and a written exam (on the discrete part)

Teaching program

Lectures Part (1) - Discrete Event Systems (7h) Discrete dynamic systems - Reminders on discrete event systems, languages and automata - Notion 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, residues and RdPs. Part (2) - Continuous systems (5h) modeled by state equations - Model-based monitoring of industrial processes - Generation of residues using state observers, observer bench and structuring of residues Tutorials including a part on computer machine Part (1): 2h of machine tutorial - Application to an air conditioning system: automaton-based diagnosis with implementation on a “Supremica” synthesis software. Part (2): 2h of machine tutorial - Application of detection and localization of sensor faults by observer bench.

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

Objective

The objective of this EC is to raise students' awareness of the problem of formal verification of the properties of critical programmed systems. The fundamentals of model-checking are presented and applied to case studies developed with the UPPAAL and SCADE tools.

Skills acquired

At the end of this EC, students will be able to provide proof of properties for automated systems subject to high normative requirements in terms of security.

Prerequisites

This EC complements the theoretical foundations acquired in the EC “Operational Safety” and “discrete event systems Modeling” of 2A.

Assessment

- Examination on computer machine (UPPAAL tool) for the formal verification of properties - Situational simulation through modeling and analysis of a case study (practical work report).

Teaching program

Modeling using communicating timed automata (formalism, modeling of synchronization channels, clock management, execution semantics). - Modeling of properties using CTL temporal logic (path and time quantifier) - Basic principles of model-checking (Kripke structure, exploration of state space). - Application to UPPAAL (timed automata) and SCADE (synchronous languages) tools.

EC 9KEISN34	Security of Automated Systems	UE 9KUISN13 S9 - SA - 03 Safety and security	? / J. Daafouz

Total hours : 16
Lecture hours : 6
Tutorials hours : 2
Practical/lab hours : 8

Objective

Autonomous and 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 autonomous and 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

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: attacks and threats - Protection system: intrusion detection, firewall Tutorials: - Study of cryptographic systems Practical work: - Role-play with an industrial application case (ENSEM Cyber suitcase platform) to identify and remedy attacks on the control of an industrial and automated system (SCADA and control automation systems)

EC 9KEISN43	Distributed Algorithms and Blockchain	UE 9KUISN14 S9 - SA - 04 Distributed systems	?

Total hours : 16
Lecture hours : 6
Tutorials hours : 2
Practical/lab hours : 8

Objective

Distributed algorithms are very useful in distributed digital systems to ensure their operation in the absence of shared memory and a common time reference (desynchronization of physical or unreliable clocks). These algorithms mainly address the inherent problems related to the distribution of functions and data between the different components of a system. The methods for solving these problems are mainly mutual exclusion, the basics of clock synchronization and the integration of blockchain technologies.

Skills acquired

Identify the main classes of algorithms for distributed systems - Implement solutions and algorithms in an integrative approach

Prerequisites

Algorithms and programming, Object-oriented programming

Assessment

- Know how to integrate and exploit distributed algorithms to implement a distributed application Assessment methods: continuous assessment (practical work notes), written exam

Teaching program

Course: - Problem statement (exclusion, time synchronization, distributed system) - Time, order and causality - Distributed mutual exclusion - Blockchain technologies (structures and components, consensus mechanism) Tutorials: - Causal dependence, logical clocks and mutual exclusion in a distributed environment Practical work: developing a distributed application with an integrative approach - TP1: sharing computation on distributed tasks in a distributed architecture - TP2: Carrying out distributed mutual exclusion - TP3: publishing data and operating a blockchain

Total hours : 16
Lecture hours : 8
Tutorials hours : 2
Practical/lab hours : 6

Objective

This course addresses the fundamental problems encountered when a computer application is built around several interacting autonomous components. It sets out these problems based on the concepts that characterize them and then presents different techniques for solving these problems.

Skills acquired

Understand and identify the fundamental problems of distributed systems (exclusion, synchronization) Master and implement solutions to these problems. Understand the basics of web services

Prerequisites

Object-oriented design and programming Computer systems and networks

Assessment

Practical exam (1/3) and on-table exam (2/3)

Teaching program

The lessons will cover the themes of mutual exclusion, synchronization of activities between processes; conceptual solutions and classical algorithms (philosophers' dinner, etc.) The main parts of the course are: Statement of problems, vocabulary and associated concepts Conceptual and software solutions: algorithms, tools (semaphores, monitors, messages, etc.) "Classical" statements and their solutions (philosophers' dinner, reader/writer, producer-consumer, sleeping hairdresser, barrier, lock, appointment, etc.) The case of web services Practical implementations in JAVA or Python will be made in order to concretize through different techniques (multi-thread, semaphore, monitor, web service, etc.) the concepts and solutions seen in class

EC 9KEISN4!	IoT systems	UE 9KUISN14 S9 - SA - 04 Distributed systems	YQ Song

Total hours : 16
Lecture hours : 5
Tutorials hours : 2
Practical/lab hours : 9

Objective

The Internet of Things (IoT) and wireless sensor networks represent a significant evolution of the Internet towards distributed cyber-physical systems. This course aims to introduce the IoT ecosystem by focusing on both data transmission protocols on the sensor network side and data distribution in the cloud.

Skills acquired

Understand the concepts of low-power protocols. Know how to develop IoT applications to collect and transmit sensor data and distribute it over the Internet/Cloud.

Prerequisites

Computer Networks Programming in Python

Assessment

The skills acquired in developing IoT applications will be assessed through practice (practical notes).

Teaching program

lecture: IoT Eco-systems: embedded platforms, transmission protocols for sensor networks (e.g. WiFi, IEEE802.15.4, Zigbee, LoRa), publisher/subscriber data distribution model (MQTT), data visualization and processing. tutorial: Sensor network simulation. lab work: - Short-range networks (XBEE) - Long-range networks (LoRa) - Sensor data distribution and processing (MQTT, Node-Red)

EC 9KEISN52	Introduction to Robotics	UE 9KUISN15 S9 - SA - 05 Robotics and Autonomous Vehicles	D. Wolf

Total hours : 16
Lecture hours : 8
Tutorials hours : 0
Practical/lab hours : 4

Objective

Acquire basic notions of robotics.

Skills acquired

Be able to build specifications for a robotics installation, particularly an industrial one

Prerequisites

ENSEM Solid Mechanics Course

Assessment

Exam: 2 hours

Teaching program

Functional diagram of a robot Classification of robots Examples of robots Sectors of application Articulated mechanical systems (AMS) Attitude of a reference in space Geometric models of AMS Generation of movements Control

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

Objective

The objective of this design office is to apply project-based learning to design, develop, and experiment with technologies and methods associated with autonomous vehicle navigation. It also allows students to learn project management through practice, develop autonomy, and apply the S5, S6, S7, and S8 courses through practice. It is dedicated to the development of a control and trajectory planning application for autonomous vehicle navigation.

Skills acquired

- Know and apply certain techniques of trajectory control and planning - Implement an application for the navigation of an autonomous vehicle

Prerequisites

Automation, programming and algorithms

Assessment

- Know how to apply control and trajectory planning techniques for navigation Assessment methods: project score

Teaching program

Definition of the solution specifications - Control and trajectory planning techniques: control models, navigation algorithms - Software development of the solution on the QCar platform (https://www.quanser.com/products/qcar/) and ROS - Validation and evaluation of the solution - Demonstration of the solution

EC 9KEJ0N54	**Mobile Applications and Internet of Things**	*UE 9KUISN17 S9 - SLE - 01 Intelligent communicating systems and security*	*T. Cholez*

Total hours : 24
Lecture hours : 6
Tutorials hours : 10
Practical/lab hours : 8

Objective

?

Skills acquired

?

Prerequisites

?

Assessment

?

Teaching program

?

EC 9KEISN73	Industrial embedded networks	UE 9KUISN17 S9 - SLE - 01 Intelligent communicating systems and security	YQ Song

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

Objective

Embedded networks in industry must meet real-time, safety, and security requirements. This course aims to introduce the main embedded networks for industrial and embedded applications: real-time Ethernet, CAN, Modbus, etc.

Skills acquired

Understand how industrial networks work. Able to model, validate, and develop a distributed real-time industrial application around an embedded network.

Prerequisites

Computer Networks Programming

Assessment

The acquired knowledge and development skills will be assessed jointly by a written exam and practice (practical work notes)

Teaching program

lecture: - Switched Ethernet - CAN (Controller Area Network) and automotive on-board application - Modbus tutorial: - CAN protocol - Time validation method for CAN messaging lab work: - CAN analysis - Development of a supervision application on Modbus

EC 9KEISN74	Security of an embedded system	UE 9KUISN17 S9 - SLE - 01 Intelligent communicating systems and security	?

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

Objective

Embedded systems using wireless radio technologies (BLE, Zigbee, ZWAVE) 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 of an embedded system in order to identify and implement protective barriers using cybersecurity methods and tools.

Skills acquired

- Analyze the risks of cyber attacks on an industrial and embedded system - Implement defense barriers (perimeter and in depth)

Prerequisites

Python programming, communication networks, cybersecurity initiation (2A S8)

Assessment

- Know how to analyze and identify the risks of cyber attacks and implement defense and protection barriers for an embedded and communicating system Assessment methods: 50% written exam + 50% practical work notes

Teaching program

Course: - Analysis of cyber risk and attacks in embedded and communicating systems: attacks and threats - Study of the security of BLE (Bluetooth Low Energy) and ZWAVE protocols - Protection and defense methods (light cryptography) Practical work: - Simulation to analyze the security and assess the risk of different IoT systems and connected objects (smart bulbs and sockets, industrial system) to identify and remedy attacks on these systems

Total hours : 20
Lecture hours : 6
Tutorials hours : 2
Practical/lab hours : 12

Objective

Distributed algorithms are very useful in distributed embedded systems to ensure their operation in the absence of shared memory and a common time reference (desynchronization of physical or unreliable clocks). These algorithms mainly address the inherent problems related to the distribution of functions and data between the different components of a system. The methods for solving these problems are mainly mutual exclusion, the basics of clock synchronization and the integration of blockchain technologies.

Skills acquired

Identify the main classes of algorithms for distributed systems - Implement solutions and algorithms in an integrative approach

Prerequisites

Algorithms and programming, Communication networks

Assessment

- Know how to integrate and exploit distributed algorithms to implement a distributed application in an embedded environment Assessment methods: continuous assessment (practical work notes), written exam

Teaching program

Course: - Problem statement (exclusion, time synchronization, distributed system) - Time, order and causality - Distributed mutual exclusion - Blockchain technologies (structures and components, consensus mechanism) Tutorials: - Causal dependence, logical clocks and mutual exclusion in a distributed environment Practical work: developing a distributed application with an integrative approach - TP1: sharing computation on distributed tasks in embedded systems - TP2: Realization of distributed mutual exclusion (synchronization of tasks) - TP3: publication of data and exploitation of a blockchain and smart contracts

EC 9KEJ0N5	Parallel and distributed programming	UE 9KUISN18 S9 - SLE - 02 Advanced Machine Architecture	S. Lefebvre / J. Mart

Total hours : 22
Lecture hours : 6
Tutorials hours : 16
Practical/lab hours : 0

Objective

?

Skills acquired

?

Prerequisites

?

Assessment

?

Teaching program

?

Total hours : 70
Lecture hours : 4
Tutorials hours : 2
Practical/lab hours : 64

Objective

?

Skills acquired

?

Prerequisites

?

Assessment

?

Teaching program

?

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

Objective

The objective is to provide students with a basic knowledge of digital imaging and its potential uses. This involves presenting the knowledge necessary for the design and implementation of digital image processing methods, ranging from acquisition (basic optics, digitization) to decision-making (classification and pattern recognition) through image representation and processing (enhancement, segmentation).

Skills acquired

Describe and use the different representations of a digital image: - Analyze the influence of acquisition conditions on the information content of a digital image. - Master and implement the basic methods and tools for image processing (enhancement, segmentation, interpretation, compression, watermarking). - Select and implement the appropriate methods according to the application context. - Master the basic methods of pattern recognition and apply them

Prerequisites

Signal Processing; Statistics and Probability; Algorithms and Programming

Assessment

Practical work report and written exam

Teaching program

Introduction to digital imaging: Definition of an image (pixels, colorimetry, etc.) Basic notions of acquisition systems (optics, device, digitization) - Basics of image processing: LUT (image inversion, contrast enhancement, etc.) Filtering (smoothing, contour detection, etc.) Mathematical morphology (erosion, dilation), global transformation (Fourier, DCT) Region segmentation, contour - Shape recognition Extraction of characteristics (local and global) Clustering (K-means), Classification (Kppv)

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

Objective

The objective of this design office is to enable the exploitation of the UrbanLoop platform of the Brabois site for the creation of an obstacle detection and capsule control application using different sensors such as camera (mono or stereoscopic), Lidar, ultrasound, etc. The objective is to design a software and hardware architecture allowing the implementation of the autonomous movement of the capsule and in particular the detection of obstacles.

Skills acquired

- Know and apply certain obstacle detection techniques and autonomous navigation - Implement an application for the autonomous navigation of an Urbanloop capsule

Prerequisites

Automation, FPGA, real-time systems, programming and algorithms

Assessment

- Know how to apply obstacle detection and autonomous navigation techniques Assessment methods: project score

Teaching program

- Definition of the solution specifications - Obstacle detection techniques using different sensors (lidar, ultrasound and camera) and feedback on the capsule servo (stop if an obstacle is detected) - Software development of the solution on the hardware platform of a capsule and on a digital target (FPGA, Micro-controller) - Validation and evaluation of the solution - Demonstration of the solution

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
2, Avenue de la Forêt de Haye
54500 Vandoeuvre-lès-Nancy

Academic year 2025-2026
Detailed curriculum 2025-2026 ISN_FISE

Semester S10

Code	Course Unit	**ECTS**	Code	Course	Coeff	*Teacher*	**Vol**	CM	TD	TP
0KSTAN01	Engineering or R&D Internship	**30**	0KSTAN10	Engineering Internship	1					

EC 0KSTAN1	**Engineering Internship**	***UE 0KSTAN01 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