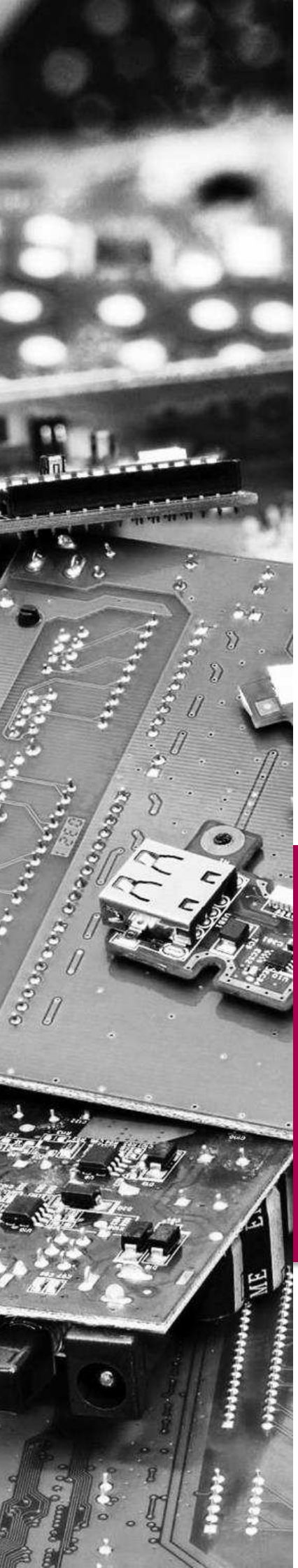


ENSEA

Beyond Engineering

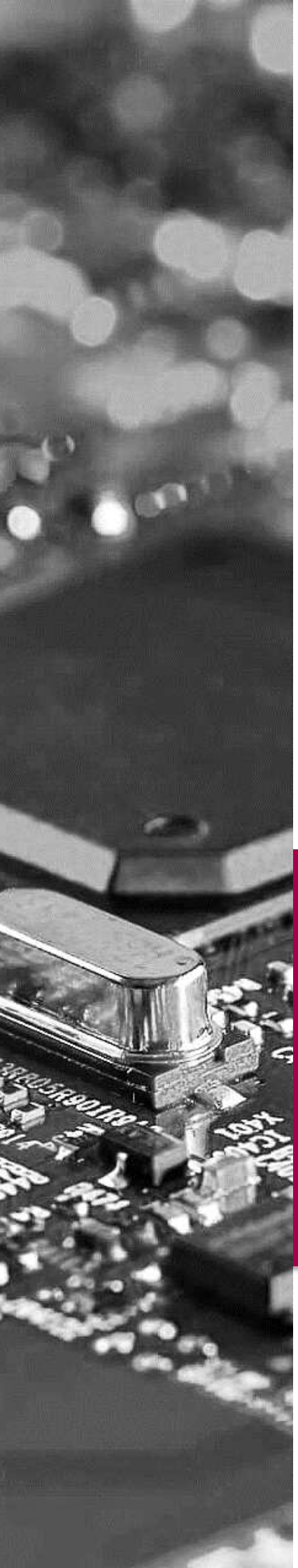
ENSEA

Ecole Nationale Supérieure de l'Electronique et de ses Applications

International Graduate Programs

Edition 2023

Index



ENSEA

Beyond Engineering

Electrical & Computer Engineering

Computer Science & Signal Processing majors

Graduate/Master Program

ENSEA – Semester 7 - English-Taught Track

Edition 2023

ENSEA Second Year Syllabus – International Program
First year of Master or Graduate studies
Signal processing and Computer Science Majors

Level	**First year of Master's Degree/Graduate/Semester 7**		
Period	Fall semester (September to January)		
Language of tuition	English		
ECTS	30		
Courses	Code	Course	ECTS
	COMPUTER_S7_MAJ	**Computer Science as Major [Composed of:]**	**6**
	DTI_2501	Microprocessors	
	DTI_2502	Object-oriented programming: JAVA	
	DTI_2506	Network fundamentals	
	DTI_2507	System programming	
	DTI_2508	Lab work	
	SIGNAL_S7_MAJ	**Signal Processing as Major [Composed of:]**	**6**
	DTI_2201	Digital Signal Processing II	
	DTI_2202	Digital Communications	
	DTI_2206	Random signals	
	ELECTRONICS_S7_MIN	**Electronics as Minor [Composed of:]**	**4**
	DEE_2301	Electronic Systems II	
	AUTOMATION_S7_MIN	**Automation as Minor [Composed of:]**	**4**
	DA_2401	Energy Conversion I	
	MANAGEMENT_PROJECT_S7	**Management & Project [Composed of:]**	**6**
	DEE_2701	Project	
	DSH_2601	Responsible and sustainable management	
	LANGUAGES_S7	**Languages [Composed of:]**	**4**
	DSH_2101	English	
	DSH_2106	French for international students	

ENSEA Second Year Syllabus – International Program
First year of Master or Graduate studies
Signal processing and Computer Science Majors

COMPUTER_S7_MAJ Computer Science as Major (6 ECTS)

DTI_2501 Microprocessors(Lectures: 16h / Tutorial classes: 8h / Lab: 16h)
This advanced module allows the understanding of the different components of a system based on a microcontroller. The objective is reached using a guided-project using a STM32 controller and peripherals.
- Interruption/exception transfer mechanism: interruption types, vectorization, interruption masking and management.
- Microcontroller peripherals: microcontroller architecture, peripherals memory, clock, timer, ADC, DAC, extern peripherals.
- Link with C language.

DTI_2502 Object-oriented programming: JAVA(Lectures: 6h / Tutorial classes: 14h / Lab: -h)
The module focuses on the object-oriented programming basis using JAVA language. The learning is done through practice guided by the development of an application. This module is complementary to the S5 C language module.
- Classes, instances, references
- Encapsulation, access
- Inheritance, polymorphism
- Error management, exceptions
- Graphical interface, events management
- Object-oriented design, design patterns

DTI_2506 Network fundamentals (Lectures: 6h / Tutorial classes: 6h / Lab: -h)
The course focuses on the design of communicating applications using a data transmission
protocol. TCP/IP and internet network are the main targets.
- General ideas of communication protocols
- OSI model, norms
- Local networks, access, routing
- TCP/IP protocol

DTI_2507 System programming (Lectures: 6h / Tutorial classes: 6h / Lab: -h)
The course focuses on programming system applications offering services to other applications. Communication between application is explained, together with multiprocesses
programming.
- Input and output at low level (open, clos, read, write, fctl)
- Pipe, socket
- Process creation (fork, exec)

DTI_2508 Lab work (Lectures: -h / Tutorial classes: -h / Lab: 16h)
The lab work consists in developing a data server accessible through the network. FTP server, HTTP, IRC.

SIGNAL_S7_MAJ Signal Processing as Major (6 ECTS)

DTI_2201 Digital Signal Processing II (Lectures: 16h / Tutorial classes: 18h / Lab: 16h)

The first module focused on characterizing discrete-time signals and digital filter in time and frequency domains. This advanced module allows:
- The analysis of the frequency contents of a signal, the definition of SNR
- The characterization of the filters (linear phase, phase shifter) effect on spectrum
- The design of the filter / its transfer function to extract the wanted signal or attenuate the unwanted components
- The implementation of the designed filter
- The quantification of the enhancement brought by filtering in terms of SNR and periodogram
Illustrations will be made on ECG signals, images… Lab work on Matlab focuses on design and implementation of filters, comparison between average and AR(1) filtering.

DTI_2202 Digital Communications (Lectures: 8h / Tutorial classes: 8h / Lab: 8h)

This module presents the digital techniques of signal transmission. The objective is to allow the students to characterize a simple communications system and determine its main performances. Lab work uses a simulation software for communications systems.

- Digital Baseband transmission: digital information representation, limited bandpass channel, intersymbol interferences, eye diagram, channel with Gaussian addition-noise, binary error rate.
- Digital modulations: main modulations principles (ASK, FSK, PSK, QAM), trajectories, constellations, spectrum efficiency, demodulation techniques, modulation performances in presence of noise.
- Introduction to channel-coding: linear-bloc codes, Hamming distance, syndrome, decoding and error correction.

DTI_2206 Random signals (Lectures: 12h / Tutorial classes: 12h / Lab: 16h)

After a general introduction on random continuous and discrete-time processes, the second order model in stationary case is only discussed using time-discrete signals. The characterization, filtering and model of signals originating from physical phenomena (speech, pressure measurement, communication signals) are viewed thanks to statistical tools.

- Random process. Second-order properties, covariance function
- Stationarity. Correlation function, application to delay estimation.
- Power spectral density and z-density. Example: detection of a sine wave inside noise.
- Mean estimator, autocorrelation estimator. Ergodism, estimators quality.
- PSD estimation: correlogram, periodogram. Wiener-Khintchine theorem, average
periodogram, windowing.
- Linear filtering of processes. Interferences formula, multipath communication.
- Processes model. AR, ARMA model, vocal tract model.

ELECTRONICS_S7_MIN Electronics as Minor (4 ECTS)

DEE_2301 Electronic Systems II(Lectures: 16h / Tutorial classes: 18h / Lab: 16h)
This module focuses on analog electronics functions and fundamental concepts. At the end of the module, the students are able to design most of analog electronic circuits.
- First harmonic approximation. Transistor model using this approximation. Non-linear behavior of amplifiers, distortion.
- Oscillators
- Phase-locked loop. Static, dynamic state, sequential detector loop
- Transmission lines model. Behavior in transient state.

AUTOMATION_S7_MIN Automation as Minor (4 ECTS)

DA_2401 Energy Conversion I (Lectures: 16h / Tutorial classes: 18h / Lab: 16h)
This course allows the study of the main static converters structures used in Power Engineering (chopper, switched-mode power supply) and presents the speed control in DC motors.
- Power semi-conductor devices and magnetic devices
- DC Power sources: batteries. Filtering.
- Chopper: step down, two-/four-quadrant, inductive storage, Single Ended Primary Inductor Converter (SEPIC)
- Speed variation of a DC motor powered by a four-quadrant chopper
Lab work are dedicated to Flyback and Forward power supplies, reversible chopper, inverter.

MANAGEMENT_PROJECT _S7 Management & Project (6 ECTS)

DEE_2701 Project (Lectures: -h / Tutorial classes: -h / Lab: 48h)
The project takes place in S7 and S8. It embodies a truly important step for the Engineer student in his studies. It is indeed the first experience over a long period of designing and realizing a prototype which involves real industrial or research constraints.
The objective is to let the student work as if he was in a R&D department. Starting from an idea, he has to
- Develop a global vision of the system
- Write a design brief
- Design the prototype
The student will encounter issues such as reading past years work from other students, writing reports, choose and buy devices for the prototype. At the end of S7, the student has an oral defense to present his work until then.

The ecological footprint of the product is studied from its design to its production. The components used are sourced by verifying that the most favorable environmental and social standards are used (ROHS, ISO 14001, etc.).

The project topics are spread on all the Engineering & Research fields of ENSEA.

DSH_2601 Responsible and sustainable management of project activities in a normative environment (Lectures: 6h / Tutorial classes: 18h / Lab:-h)

The first part of the course allows students to deepen the project approach on :
- The project realization phase: operational planning by breaking down the project into work packages (WBS), management of responsibilities (OBS/RACI) and the diagram of
deliverables and flows.
- The monitoring and control phase: project monitoring and coordination resources (human, material, financial) with deliverables and milestones (PERT, GANTT and agile management tools such as SCRUM, DMAIC). Project duration and costs by optimizing the triptych "Costs/Delays/Resources" in a SD/RS ENVIRONMENT
- The closing phase of the project with the project debriefing/feedback and the closing meeting.

In addition to the traditional tools, students are trained in tools for monitoring the project in relation to SD and CSR (Sustainable Development Logbook (Sustainable Development Logbook - SDLC®, tools for evaluating the environmental and environmental and societal risks of a project - risk rating matrix etc.)

The second part of the course is a practical application of the lessons of the module "Electronic project and its responsible and sustainable management". The objective is to reinforce the students' skills in the fields of standardization and responsible engineering.
In particular, the students deepen their knowledge of integrated environmental management system (QSE) and more particularly, the societal responsibility of an organization (CSR). The certification process of an organization is considered to introduce students to a continuous improvement approach.
The TDs favor an edutainment approach (or in the form of a serious game) by through the implementation, in an organization, of policies that integrate a sustainable management of the organization. The teaching in TD can also take the form of the realization of a CSR/Audit diagnosis (Management or Process).

LANGUAGES_S7 Languages (4 ECTS)

DSH_2101 English(Lectures: -h / Tutorial classes: 26h / Lab: -h)
The goal of this year is to prepare for the international experience, either academic or internship mobility. Focus will be given to resume and cover letter redaction, Business English, intercultural workshop, the way to speak in professional context or daily life, advanced notions on linguistic aspects. Workshops dedicated to different language certificates can be also suggested.

DSH_2106 FLE (French for foreigners) (Lectures: -h / Tutorial classes: 24h / Lab: -h)
The main goal of this class is training the foreign students through communication fundamentals for everyday life, proposing them an introduction to French culture and civilization and more advanced knowledge in order to work in a French company during the final internship period.

ENSEA

Beyond Engineering

Electrical & Computer Engineering

Signal Processing major
Or Electronics major

Graduate/Master Program

ENSEA – Semester 8 - English-Taught Track

Edition 2023

ENSEA Second Year Syllabus – International Program
First year of Master or Graduate studies
Signal processing Major

Level	**First year of Master's Degree/Graduate/Semester 8**		
Period	Spring semester (January to August)		
Language of tuition	English		
ECTS	30		
Courses	Code	Course	ECTS
	SIGNAL_S8_MAJ	**Signal Processing as Major [Composed of:]**	**6**
	DEE_2211	Statistics and numerical methods	
	DEE_2216	Information theory and multimedia compression	
	ELECTRONICS_S8_MIN	**Electronics as Minor [Composed of:]**	**4**
	DEE_2311	Analog modulations & Noise	
	DEE_2312	Electromagnetic Compatibility, Signal Integrity	
	MANAGEMENT_PROJECT_S8	**Management & Project [Composed of:]**	**6**
	DEE_2711	Project	
	DSH_2611	Industrial Management	
	DSH_2612	Recruitment meeting	
	LANGUAGES_S8	**Languages [Composed of:]**	**4**
	DSH_2111	English	
	DSH_2116	French for international students	
	OPTION_S8	**Elective course**	**6**
	STAGE	**Engineer assistant internship**	**4**

SIGNAL_S8_MAJ Signal Processing as Major (6 ECTS)

DEE_2211 Statistics and numerical methods(Lectures: 14h / Tutorial classes: 12h / Lab: 16h)

This course gathers applied mathematics methods. Two main chapters – estimation and significance tests – are seen from both the aspects of inferential and industrial statistics. The first point of view allows to solve random signals problems, only using time-method, and some telecommunications problems (decoding with maximum likelihood). Other topics, dealing with industrial statistics and Engineer general knowledge, are presented, such as Chi-Squared testing and quality control. Optimization problems coming from statistics are solved with a numerical method. Conversely, statistical methods allow the solution of optimization problems : a topic over stochastic optimization is discussed.

- Random vectors, random processes, statistical samples management
- Likelihood of a statistical model
- Estimation one-point or over a range
- Significance testing: parametric (Neyman-Pearson) and non-parametric (Chi-Squared)
- Finite differences
- Multiple-variable Differential Calculus
- Optimization: gradient method, Newton method, least-squared method
- Stochastic optimization

DEE_2216 Information theory and multimedia compression (Lectures: 10h / Tutorial classes: 10h / Lab: 16h)

This course introduces the fundamentals in coding theory, source coding, error correction coding. Multimedia compression is then discussed (image, audio, video). JPEG images compression will be the golden thread since it includes lossless and lossy compression.

- Information theory and digital communications: entropy, mutual information, source coding (Shannon theorem, Huffman algorithm, Markov sources), differential entropy of continuous random variables, Gaussian channel capacity.
- Lossless compression, reversible: statistical algorithms, dictionary-based methods, arithmetic compression
- Lossy compression, non-reversible: scalar and vector quantification, transformations and preparation to compression, restitution quality versus compression rate.
- Channel coding: discrete channel without memory, capacity, Shannon theorem for coding theory, binary linear codes.
- JPEG norms.

ELECTRONICS_S8_MIN Electronics as Minor (4 ECTS)

DEE_2311 Analog modulations & Noise(Lectures: 6h / Tutorial classes: 6h / Lab: 8h)

This course allows the study of signal transmission, in its analog aspect.

- Noise
- Amplitude modulation
- Frequency modulation
-

DEE_2312 Electromagnetic Compatibility, Signal Integrity (Lectures: 8h / Tutorial classes: 10h / Tutorial classes machine: 4h / Lab: 8h)

This course focuses on different electromagnetic interferences and their effects on electronic systems, especially the signal integrity issues and power (crosstalk, electromagnetic interferences, overshoot, multiple reflection, signal skew…). The idea is to make students aware of these issues as soon as the design of the circuit.

- Definitions and rules specific to Electromagnetic Compatibility
- Electromagnetic interferences. Classification by origin, time, spectrum, coupling type (conduction, , both), differential and common propagation mode, frequency and time characterization.
- Coupling mechanism in harmonic state and transient state.
- Screening effect
- Devices and specific methods of EC protection

ENSEA Second Year Syllabus – International Program
First year of Master or Graduate studies
Electronics Major

Level	**First year of Master's Degree/Graduate/Semester 8**		
Period	Spring semester (January to August)		
Language of tuition	English		
ECTS	30		
Courses	Code	Course	ECTS
	ELECTRONICS_S8_MAJ	**Electronics as Major [Composed of:]**	**6**
	DEE_2311	Analog modulations & Noise	
	DEE_2312	Electromagnetic Compatibility, Signal Integrity	
	DEE_2316	Electronic Systems III	
	SIGNAL_S8_MIN	**Signal Processing as Minor [Composed of:]**	**4**
	DEE_2211	Statistics and numerical methods	
	MANAGEMENT_PROJECT_S8	**Management & Project [Composed of:]**	**6**
	DEE_2711	Project	
	DSH_2611	Responsible and sustainable marketing for the engineer	
	DSH_2612	Recruitment meeting	
	LANGUAGES_S8	**Languages [Composed of:]**	**4**
	DSH_2111	English	
	DSH_2116	French for international students	
	OPTION_S8	**Elective course**	**6**
	STAGE	**Engineer assistant internship**	**4**

ELECTRONICS_S8_MAJ Electronics as Major (6 ECTS)

DEE_2311 Analog modulations & Noise(Lectures: 6h / Tutorial classes: 6h / Lab: 8h)
This course allows the study of signal transmission, in its analog aspect.
- Noise
- Amplitude modulation
- Frequency modulation

DEE_2312 Electromagnetic Compatibility, Signal Integrity (Lectures: 8h / Tutorial classes: 10h / Lab: 8h)
This course focuses on different electromagnetic interferences and their effects on electronic systems, especially the signal integrity issues and power (crosstalk, electromagnetic interferences, overshoot, multiple reflection, signal skew…). The idea is to make students aware of these issues as soon as the design of the circuit.
- Definitions and rules specific to Electromagnetic Compatibility
- Electromagnetic interferences. Classification by origin, time, spectrum, coupling type (conduction, , both), differential and common propagation mode, frequency and time characterization.
- Coupling mechanism in harmonic state and transient state.
- Screening effect
- Devices and specific methods of EC protection

DEE_23126 Electronic Systems III (Lectures: 10h / Tutorial classes: 8h / Tutorial classes m: 2h Lab: 16h)
We study in this major some applications, from the point of view of analog signal, systems and associated components. Simulation tools specific to the field will be used in lectures and in practical sessions.
Analog demodulations in the presence of noise, phase noise.
Noise in linear quadrupoles, noise factor.
Link budget of a radio link or a wire link.
Operation of electronic labels. RFID. Contactless charger.
Atomic clocks, phase noise. GPS systems.
Low voltage, low consumption electronics. Example: MOS in low inversion regime.

SIGNAL_S8_MIN Signal Processing as Minor (4 ECTS)

DEE_2211 Statistics and numerical methods(Lectures: 14h / Tutorial classes: 12h / Tutorial classes m: 4h / Lab: 16h)

This course gathers applied mathematics methods. Two main chapters – estimation and significance tests – are seen from both the aspects of inferential and industrial statistics. The first point of view allows to solve random signals problems, only using time-method, and some telecommunications problems (decoding with maximum likelihood). Other topics, dealing with industrial statistics and Engineer general knowledge, are presented, such as Chi-Squared testing and quality control. Optimization problems coming from statistics are solved with a numerical method. Conversely, statistical methods allow the solution of optimization problems : a topic over stochastic optimization is discussed.

- Random vectors, random processes, statistical samples management
- Probability of a statistical model
- Estimation one-point or over a range
- Significance testing: parametric (Neyman-Pearson) and non-parametric (Chi-Squared)
- Finite differences
- Multiple-variable Differential Calculus
- Optimization: gradient method, Newton method, least-squared method
- Stochastic optimization

Core subjects & Option

MANAGEMENT PROJECT_S8 (4 ECTS)

DEE_2711 PROJECT Lab : 40h

The project initiated during the previous semester is continuing and will result in

at the end of the year, to the writing of an activity report given during the

the final technical demonstration

DSH_2611 Responsible and sustainable marketing for the engineer

Lectures:10H /Tutorial Classes: 12h

The course should enable students to understand the fundamental knowledge and tools of marketing, such as defining a marketing approach, perform a marketing diagnosis (PESTEL,

(PESTEL, SWOT), develop a marketing strategy (segmentation, positioning mapping), build a marketing mix and plan and follow up marketing actions.

Students must understand the concept of responsible and sustainable marketing

and make the link with the CSR commitment of an organization. For example, the need to analyze the impact of market positioning on the environment, define operational marketing methods and tools to build a responsible and sustainable offer in coherence with the ecosystem (sustainable or eco-responsible products, non-commercial communication

responsible consumption, short circuits/channels of distribution and sales channels).

Students can transpose the concepts of responsible and sustainable marketing to the case of an engineering project (ethical framework, short circuit, sustainability...). They learn to position engineering projects sustainably by developing a strategic and operational vision of the main SD and CSR issues.

They must also know how to manage customer satisfaction throughout an throughout an engineering project in a sustainable perspective.

The Tutorial classes (Tds) favor an edutainment approach (or in the form of a serious game) which consists in designing and marketing strategy in line with its ecosystem.

DSH_2612 Job Interview Training Tutorial classes : 4h

This training is intended for all students to enable them to better apprehend the job or internship interviews they will have to face at the end of their studies.

The activity is given by industrialists specialized in the recruitment of young graduates.

- Presentation of the system, general rules, preparation (analysis of job offers),

- Personalized interview,

- Conclusion and feedback.

LANGUAGES_S8 Languages (4 ECTS)

DSH_2111 English(Lectures: -h / Tutorial classes: 24h / Lab: -h)
The goal of this year is to prepare for the international experience, either academic or internship mobility. Focus will be given to resume and cover letter redaction, Business English, intercultural workshop, the way to speak in professional context or daily life, advanced notions on linguistic aspects. Workshops dedicated to different language certificates can be also suggested.

DSH_2116 FLE (French for foreigners) (Lectures: -h / Tutorial classes: 20h / Lab: -h)
The main goal of this class is training the foreign students through communication fundamentals for everyday life, proposing them an introduction to French culture and civilization and more advanced knowledge in order to work in a French company during the final internship period.

OPTION_S8 Elective course (6 ECTS)

[Choose one]

DEE_2802 Drones (Lectures: 36h / Tutorial classes: -h / Lab: 28h)

This elective course is an introduction to the design, realization, instrumentation and remote control of drones. These techniques could be generalized to other autonomous mechatronics systems.

Contents

- Notions of mechanics
- Aerodynamics
- Motorization
- Sensor specifications (accelerometer, gyroscope, magnetometer, GPS…)
- Sensor data fusion (Complementary or Kalman filter)
- Control (PID, multivariable)
- Microcontroller (STM32 family)

Laboratory project

- Testing a pre-built quadcopter drone
- Acquisition (I2C/SPI protocols) and processing of sensors data (accelerometer, gyroscope, magnetometer…)
- Generation of PMW control signals for motors
- Dynamic modeling and simulation with Matlab/Simulink
- Feedback and PID control

DEE_2807 Internet of Things (Lectures: 36h / Tutorial classes: -h / Lab: 28h)
IoT networks interconnect embedded physical objects such as distributed control systems used in autonomous vehicles and sensor networks used in structural health monitoring and smart cities. According to predictions, IoT will account for 45% of all Internet traffic by 2020, showcasing the importance of IoT applications.
This elective course focuses on the architectures and protocols of IoT communication networks; we will study cases such as wireless sensor networks and vehicular IoT networks (V2V, V2X, X2V to assist driving). The option covers a wide range of topics, starting from the physical layer (PHY), and moving to IoT MAC and network layers (802.15.4, 6LoWPAn, ZigBee, etc.). Special topics, including IoT security protocols – IPSec. DTLS, etc., will also be covered. Students will have the chance to get introduced to the realm of IoT and experiment with intelligent, interconnected objects, they can potentially conceptualize, design and develop in the future as engineers.
Contents
• Communication networks for IoT
• Fundamental trade-offs between rate, connectivity, latency
• Wireless sensor networks
• Energy consumption, energy harvesting
• IoT PHY: NB-IoT
• Networking for IoT, TCP-IP, IPv6, 6LoWPAN, ROLL/RPL
• IoT Protocols, 802.15.4, ZigBee, RIOT, CoAP
• IoT Security, DTLS, IPSec
• Automotive IoT, V2V, V2X, X2V

Laboratory topics:
Laboratory sessions include MatLab® based experiments, experimentation with real IoT devices and remote access experimentation using the IoT FIT Lab at INRIA Saclay https://www.iot-lab.info/.

Partners: Huawei, PSA

DTI_2811 DITN_2810 Artificial Intelligence and Big Data (Lectures: 36h / Tutorial classes: -h / Lab: 28h)
This elective course is an introduction to artificial intelligence and its application to the processing of big quantities of data. Classification and prediction questions will be studied through different AI methods in order to find solutions for automatic image indexation or for recommendation systems.

Contents
- Data mining, introduction to data bases
- Statistical learning, linear classifier, neuron networks, decision trees
- Introduction to deep learning
- Visual recognition, image interpretation
- Recommendation systems, user profile generation

Partners: Criteo, Qwant

DTI_2811 Image and Virtual Reality (Lectures: 36h / Tutorial classes: -h / Lab: 28h)

This elective course introduces digital signal processing for images, computer vision, virtual and augmented reality. After formal lecturing on these concepts, students will develop a project in teams of two students.

Contents

- Image generation, camera types
- Image processing, linear filtering
- Mathematical morphology, pattern recognition (Hough transform), segmentation
- Computer vision: camera calibration, stereovision, structured light
- Virtual reality: VR helmets technology, 3D modeller, 3D engine
- Augmented reality: effects insertion, image synthesis

Partners: Illumination McGuff, Morpho, Onx, SNCF

DSH_2812 Human-centered design (Lectures: 36h / Tutorial classes: -h / Lab: 28h)

This option is based on the assumption that engineers have a responsibility not to design more products that are useless, counterintuitive or difficult to use. Thus, it presents the methods and techniques for the design, realization and evaluation of user-friendly and efficient human-machine interfaces. It also presents theories and models that allow us to better understand the user's behavior (decision making, cognitive, cognitive bias, development of expertise) interactive systems. The teaching covers both software aspects (information visualization) and software aspects (information visualization, interactive techniques, Artificial Intelligence), hardware (STM, sensors and actuators) and human factors (user-centered design, prototyping, evaluation, perception). Objectives:

- Introduce the basic principles of user-centered design.
- Know the design and development cycle of an interactive system.
- Understand a set of methods for user requirements analysis, system prototyping methods, and system evaluation methods.

These methods are directly implemented through a project that will result in an iteration of project that will result in an iteration of low-fidelity prototypes.

ENSEA

Beyond Engineering

Biomedical Engineering

Graduate/Master Program

ENSEA – Semester 9 EVE - English-Taught

Edition 2023

Biomedical Engineering
ENSEA - EVE 3rd Year Academic Track

Level	**Second year of Master's Degree/Graduate/Semester 9**		
Period	Fall semester (September to January)		
Language of tuition	English		
ECTS	30		
Courses	Code	Course	ECTS
	EVE_1	**Biomedical Panorama [Composed of:]**	**6**
	EVE_3340	Smart Biosensors	
	EVE_3350	Medical Imaging	
	EVE_3371	Ethics	
	EVE_2	**Sensors [Composed of:]**	**5**
	EVE_3310	Sensors and conditioning	
	EVE_3324	Physics	
	EVE_3321	Transverse project: Sensors	
	EVE_3	**Acquisition [Composed of]**	**5**
	EVE_3317	Acquisition Systems	
	EVE_3322	Transverse project: Acquisition	
	EVE_4	**Signals [Composed of:]**	**5**
	EVE_3316	Signal characterization	
	EVE_3323	Transverse project: Signal	
	EVE_5	**Image [Composed of:]**	**4**
	EVE_33XX	Practical Deep Learning	
	EVE_3351	Image processing	
	EVE_3352	Image reconstruction	
	EVE_3370	Practical Deep Learning	
	SH-3EME	**Humanities [Composed of:]**	**5**
	DSH_3000	Responsible and sustainable management of human resources in a complex environment	
	DSH_3060	English	
	DSH_3061	FLE (French for foreigners) or Spanish or German	

Biomedical Engineering
ENSEA - EVE 3rd Year Academic Track

EVE_1 Biomedical Panorama (6 ECTS)

EVE_3340 Smart Biosensors (Lectures: 22h / Tutorial classes: 4h / Lab: 8h)
This course aims to present the different ways of interfacing the biology with electronics. To this aim, the up to date basics of cellular function are also presented.
In particular, the following topics are covered:
- Intelligent implantable systems
- Tissue/sensor interface
- Cell biology: study of cells, their components and their interactions.
- Inflammatory reaction: mechanism and case study in the context of the implementation of a tissue-engineered product for burn victims.
- Ethics, preclinical study, production and clinical trial: a case study in the smart bandage framework.

As a common thread concrete application of electronics to the characterization of cellular reactions, to the monitoring of phenomena such as the fibrotic reaction (response to the presence of an implanted sensor), and practical illustrations in the context of cardiac stimulation or functionalized connected implants (stent type) are presented.

EVE_3350 Medical Imaging (Lectures: 38h / Tutorial classes: -h / Lab: -h)
The objective of this course is to present the physical and functional principles of the different anatomical and functional imaging modalities of organs that contribute to medical diagnosis. This course is combined with visits to medical facilities with the equipment presented.
- Nuclear imaging. MRI, PET, Fluoroscopy.
- X-ray imaging. Radiography, Tomography.
- Electrophysiological imaging. Electroencephalography,
- Magnetoencephalography.
- Ultrasound imaging. Ultrasound.
- Tomographic methods.

EVE_3371 Ethics (Lectures: 12h / Tutorial classes: -h / Lab: -h)
The objective of this course is to open to ethical reflection, with an emphasis on issues specific to the biomedical and environmental fields. The following topics are covered
- ethical, environmental and societal debates raised by technological innovation
- organizational dynamics within companies, and in particular the trade-off between economic performance and social and environmental responsibility

The working approach alternates theoretical and methodological contributions, group reflection, practical case studies, and reference to concrete professional situations.

EVE_2 Sensors (5 ECTS)

EVE_3310 Sensors and conditioning (Lectures: 14h / Tutorial classes: 12h / Lab: -h)
The goal of this course is the design of measurement chains and associated electronics, from the sensor of classical physical quantities, such as pressure or acceleration, to the conditioning of the analog signal.
- Measurement chains. The various elements of a measuring chain, characteristics, accuracy of a measuring chain.
- Instrumentation and isolation amplifiers. Objectives and realization, common mode rejection, guard circuit, technological choices.
- Analog to digital conversion. The different types of converters, characteristics, choice of a CAN.
- Temperature sensors.
- Deformation, force and pressure sensors.
- Accelerometers. Principle of operation of acceleration sensors, characteristics, applications.
- Biomedical instrumentation.
- Introduction to microsystems.

EVE_3324 Physics (Lectures: 10h / Tutorial classes: 10h / Lab: -h)
This module provides complementary physics courses in several areas of biomedical, life and ecosystems, with the objective of giving students skills in modelling and/or numerical simulation. The focus is on radiation-matter interactions, including their extensions into imaging, electrochemical sensors, optics, lasers and spectroscopy. Radiation-matter interactions. Ionizing radiation. Radioactivity. Compton effect. Cherenkov effect. Sources, collimators. CCD sensors and associated optical systems. Optical fiber, propagation, interfaces, applications. Laser physics, coherence, beam control, applications. Spectroscopy. Electrochemistry and applications.

EVE_3321 Transverse project, Sensors part (Lectures: -h / Tutorial classes: -h / Lab: 28h)
The objective is to put into practice the skills acquired through the development of a complete biological data acquisition and processing chain. Within the framework of the 'Sensors' module, the first step is to characterize the sensors useful for the project.

EVE_3 Acquisition (5 ECTS)

EVE_3317 Acquisition systems (Lectures: 8h / Tutorial classes: 16h / Lab: -h)
This teaching allows to develop the necessary skills in the design of data acquisition chains on computer. It focuses on different means of acquisition such as acquisition cards connected to the computer, but also the use of short-range wireless communications (Zigbee protocol).
An introduction to human-machine interfaces is presented through the graphical development environment (LabVIEW), in ANSI C (LabWindows), as well as the "Java Native Interface" allowing to interface C and Java languages.
The necessary prerequisites are the basics of analog electronics, microprocessors, as well as the programming languages C and Java.

EVE_3322 Transverse project, Acquisition part (Lectures: -h / Tutorial classes: -h / Lab: 40h)
The objective is to put into practice the skills acquired through the development of a complete chain of acquisition and processing of biological data. Within the framework of the 'Acquisition' module, the aim is to create an acquisition chain as well as a man-machine interface. The acquisition of a rigorous object-oriented development methodology, as well as the reliability and security of the software are highlighted.

EVE_4 Signal (5 ECTS)

EVE_3316 Signal characterization (Lectures: 24h / Tutorial classes: 4h / Lab: -h)
The main objective of this course is to acquire, through a contextualized and applicative implementation, the methods and tools to analyze signals with physiological characteristics (electrocardiogram, plethysmogram, electroencephalogram, ...) at three levels:
- Capture, denoising;
- Extraction of characteristic parameters with clinical value;
- Machine Learning for the early detection of physiological and pathological events.

Through a project-oriented approach, this course allows:
- To consolidate the basics of the first and second year in signal processing (random signals, spectral analysis, optimal filtering and adaptive algorithms, application to noise and artifact reduction, random process modeling). To implement them in the context of an application to the extraction of diagnostic information from an ECG acquisition (Electrocardiogram) and to focus on a recent approach involving the model of temporal observation of the signal and the integration of a priori knowledge on the latter (shape, noise ...);
- To acquire skills in Machine Learning / Artificial Intelligence in order to perform automatic detection of pathologies and to characterize them (Principal Component Analysis, kNN, Bag of Words, Boosting, Deep Learning) and to implement them in the context of electrophysiological signals. Applications to other areas of diagnostic assistance may also be considered in order to vary the panorama of implementation.

EVE_3323 Transverse project, Signal part (Lectures: -h / Tutorial classes: -h / Lab: 40h)
The objective is to put into practice the skills acquired to develop a complete chain of biological data acquisition and processing. Within the framework of the 'Signal' module, precise expectations are defined for each project but the implementation of a Machine Learning algorithm is required.

EVE_5 Image (4 ECTS)

EVE_3353 Practical Deep Learning (Lab: 8h)
The objectives of this course are to present some of the most used programming tools to compute Deep Learning models. These objectives are two-fold : provide the student the means to develop a neural network, and to grow an interest for the student in deepening its understanding of neural network. This course will focus on Deep Learning applied for biomedical image processing in a supervised way. The following points will be studied :
• biomed
• Use of Python for Machine Learning and specific libraries (numpy, pandas, pytorch...)
• Good habits for Deep Learning (dataset separation, normalisation, shuffle...)
• Defining a neural network and choosing appropriate parameters (type of layers, loss function, learning rate...)
• Result analysis and tuning hyperparameter (Learning curve, number and type of layers or filters...)

EVE_3351 Image processing (Lectures: 12h / Tutorial classes: -h / Lab: 12h)
The objective of this course is to present the algorithmic tools of digital image processing and more specifically those applied to medical images.
- Image formation. CCD sensors, CMOS and tube cameras. Image acquisition cards. LUT and false color. Spatial sampling. Image corrections.
- Main image processing. Global transforms: Fourier, Hadamard, Walsh to Cosine and JPEG transforms. Image filtering by FFT. Local transforms: Neighborhoods 4 and 8 related. Filtering: averaging, median, Nagao. Contour detection: gradients and Laplacians mono and multi-scale. Mathematical morphology: erosion, dilation, opening, closing, hit or miss transformation. Top hat transformation, morphological gradient. Hough transforms, detection of line segments, circles and objects. Texture models: co-occurrence matrices and fractal dimension. Image segmentation: adjacency graph, MPEG4. Image restoration.
- Processing based on optimization methods. Active contours. Noise and texture detection using partial differential equations.
This class requires a minimum of 8h of autonomous practical work.

EVE_3352 Image reconstruction (Lectures: 8h / Tutorial classes: -h / Lab: 12h)
An increasing number of biomedical imaging techniques do not directly produce images. The latter are formed as a result of a reconstruction process. This course presents the methods that allow such reconstructions in MRI, CT, fDOT, ECG and super-resolution microscopy. The exercises and applications focus mainly on MRI and CT: we present the acquisition techniques and show how, in these cases, imaging can be modeled as an inverse problem. Finally, we present numerical methods adapted to the resolution of inverse problems in biomedical imaging such as sub-programs and file access. Applications of description and modeling in VHDL of some circuits and their simulation, synthesis and implementation on FPGA-based target boards will be developed.
This course also proposes to acquire an in-depth knowledge of the structures and organizations of digital signal processing-oriented systems (DSP), in particular Sharc DSPs. The architecture of the processor is presented, with the associated functionalities: fixed- and floating-point operations; contribution of unit execution parallelism, interest of the pipeline; interrupt management; inputs / outputs; DMA communications; serial links; ... The development tools used to program the DSP mix C language and assembler: extensions in C, mixing C and assembler in advanced programming, parameter passing, stack management.

EVE_3370 Conferences (Lectures: 10h / Tutorial classes: -h / Lab: -h)
The conferences provide an opportunity to discover industrial applications in the field of biotechnology, with themes varying from one year to the next. A majority of these conferences are given by former students of the option who also present their professional background.

SH_3EME Humanities (5 ECTS)

DSH_3000 Responsible and sustainable management of human resources in a complex environment

(Lectures: 16h / Tutorial classes: 6h / Lab: -h)

The course presents the evolution of organizations in a complex environment (team management, corporate culture in a multicultural context, professional project through the dynamics and management of evolutions). It emphasizes the strategic role of human resources management in a CSR context (Quality of Life at Work - OHS) in order to prepare engineering students (guided by the 26000 standard) for their role as project managers, project leaders or employees of a project team.

It introduces the notions of labor law that are essential for engineers (employment contracts, expatriation, work environment in the company) by integrating the social and societal concerns of the company.

The practical courses allow, through an edutainment approach (or in the form of a serious game):

- to implement an HRM that values responsibility and ethics (Remuneration, Training, Skills management, Health and Safety at work).
- Identify good practices to implement a CSR policy.

DSH_3060 English (Lectures: -h / Tutorial classes: 24h / Lab: -h)

The objective of the third-year courses is to make the students able to work in English and have a good command of the language.

The goal is achieving a professional use and to reach, at least, a B2 level requested do obtain the degree.

Two third-year options are grouped together for English courses. Level groups can be formed. The students will be able to work on different aspects of life professional (communication in different settings, in the office, abroad, in seminars, through writing, orally, case studies...), by carrying out work groups and putting in practice the knowledge they have acquired throughout their training.

DSH_3061 FLE (French for foreigners) (Lectures: -h / Tutorial classes: 24h / Lab: -h)

The main goal of this class is training the foreign students through communication fundamentals for everyday life, proposing them an introduction to French culture and civilization and more advanced knowledge in order to work in a French company during the final internship period.

ENSEA

Beyond Engineering

Computer Science and Systems

Graduate/Master Program

ENSEA – Semester 9 IS - French-Taught

Edition 2023

Computer Science and Systems
ENSEA - IS 3rd Year Academic Track

Level	**Second year of Master's Degree/Graduate/Semester 9**		
Period	Fall semester (September to January)		
Language of tuition	French		
ECTS	30		
Courses	Code	Course	ECTS
	IS_1	**Digital Circuit Design [Composed of:]**	**5**
	IS_3431	Digital circuit design	
	IS_2	**System on Chip [Composed of:]**	**5**
	IS_3432	System on Chip	
	IS_3	**Systems and Networks [Composed of]**	**5**
	IS_3433	Systems and Networks	
	IS_4	**Algorithmics [Composed of:]**	**5**
	IS_3434	Algorithmics	
	IS_5	**Software Engineering [Composed of:]**	**5**
	IS_3435	Software Engineering	
	IS_3450	Conferences	
	SH-3EME	**Humanities [Composed of:]**	**5**
	DSH_3000	Responsible and sustainable management of human resources in a complex environment	
	DSH_3060	English	
	DSH_3061	FLE (French for foreigners) or Spanish or German	

Computer Science and Systems
ENSEA - IS 3rd Year Academic Track

IS_1 Digital Circuit Design (5 ECTS)

IS_3431 Digital circuit design (Lectures: 16h / Tutorial classes: 8h / Lab: 44h)
This course presents the digital circuit design methodology for information processing
Starting from the definition of the specifications. The different types of circuits (ASIC, CPLD, PLA, FPGA) are presented. The tools for computer assisted design are presented as well as the languages of description and modeling of hardware such as VHDL, VHDL-AMS, and some notions of Verilog. Some aspects of advanced VHDL modeling techniques are presented such as subprograms and file access. VHDL description and modeling applications of some circuits, then their simulation, synthesis and implementation on FPGA-based target boards will be explored. This course also offers the opportunity to acquire knowledge of in-depth analysis of system structures and organizations, digital signal processing oriented (DSP), particularly DSP Sharc. The architecture of the processor is presented, with the associated functionalities: operations with fixed and floating point; contribution of parallelism, interest of the pipeline; management of interruptions; inputs / outputs; DMA communications; serial links... Development tools used for programming the DSP mixes C language and assembler: extensions in C, mixing C and assembler for advanced programming, parameter passing, stack management.

IS_2 System on Chip (5 ECTS)

IS_3432 System on Chip (Lectures: 14h / Tutorial classes: 4h / Lab: 44h)
The complexity of digital systems is growing rapidly causing an increase in the cost of development. Today's applications integrate on a single chip a complete system (SoC) with several processing cores (CPU, DSP, ASIC, Microcontrollers) associated with IP blocks, I/Os and memory elements. The conception of these systems requires new design and global validation methods before its realization (joint software/hardware design).
- Organization of a design process for a SoC
- Hard and soft IP concepts: performance and flexibility
- System Description Languages (SystemC)
- Design of reusable macros and their integration
- Checking of complex systems
- Reconfigurable systems (RSoC)
- FPGA-SoPC approach (System-on-Programmable
Chip)
- Processor cores in SoPC: NIOS, MicroBlase, ARM, LEON, etc.
- Communication bus: Amba (ARM), CoreConnect (IBM), AVALON (Altera).

IS_3 Systems and Networks (5 ECTS)

IS_3433 Systems and Networks (Lectures: 8h / Tutorial classes: 4h / Lab: 56h)
The objective of this module is the knowledge of mechanisms and low-level software processes used in modern systems. Two levels are explored: a
machine level, and a network level. At the machine level, the following elements are studied:
- Kernel functions, memory management, operation of system calls, startup.
- Notion of process. Notion of task. Allocation. Scheduling.
- Communication between tasks, resource management, IPC, message queue. Memory allocation, mapping, interruptions, I/O, module programming core.
- Disk management. Management of blocks and inodes, cache management, file search, links
- File management. Opening, sharing, locking, pipes.
- Implementation on i80x86 platform.
At the network level, the following points are presented:
- TCP/IP network bases, data exchange protocols (HTTP)
- Common data formats (JSON, XML).
- REST architecture, Web API frameworks (Swagger).
- Deployment of software solutions in distributed environments.
These skills are used for the realization of a multiplayer videogame on TCP/IP networks.

IS_4 Algorithmics (5 ECTS)

IS_3434 Algorithmics (Lectures: 10h / Tutorial classes: 6h / Lab: 48h)
The main objective of this course is the acquisition of skills for finite-state problem solving using algorithms. This subject is incrementally explored, and, in each case, illustrated by numerous examples. The course begins with the presentation of the recursive approaches, which allow to solve the most common problems, such as the search for the best combination. Then, the tree-level formalism generalizes this first approach. This makes it possible to better understand the processes involved, but also to design more efficient algorithms in terms of time of calculation and memory consumption. The tree-level formalism is then extended to graphs, which allows to solve more complex problems, such as flow problems. Finally, these notions are brought together around formalisms allowing the description and the efficient resolution of all finite-state problems.
The advanced algorithms require significant computing resources. In order to conduct them in the most efficient way, the parallelization approaches of the treatments are presented. It begins with the use of SIMD processor instructions, where a single instruction can process multiple data. Then, the parallelization on several processors is taught, as well as all the issues related to multi-thread programming: synchronization, signals, resource sharing, etc. These principles will also be presented for the operation of treatment units massively parallel, like GPUs. Finally, the techniques for the distribution of calculations in data centers are presented, with a special focus on solutions based on the map-reduce paradigm and its implementation with the tools of the Hadoop system.
These skills are then exploited for the realization of artificial intelligence within a video game.

IS_5 Software Engineering (5 ECTS)

IS_3435 Software Engineering (Lectures: 12h / Tutorial classes: 8h / Lab: 48h)
This course starts with the presentation of formal tools used for the design of software solutions. This includes the realization of various elements such as the conception of specifications and the design of diagrams. This course will be based first and foremost on the UML formalism to achieve these objectives. Then, recaps in object-oriented programming will be proposed in these formal contexts, allowing to make the link between abstraction and implementation. The most common design schemes will also be taught, both in a formal way with UML and in concrete way with Java and C++. Finally, the main IT tools for the organization and realization of software will be presented: compilation systems, version, validation and project management.
The course also presents an introduction to project management. On the software engineering side, notions such as constraints on a project, V-shaped software development cycle, quality, software modeling methods and the associated tools will be explored. On the project management side, several fundamental concepts will be presented: deadline management, cost management and team management. A final assignment concludes this part so that the students are put in real-life situations. Students will gather in teams, process the development that is proposed and thus will put into practice the concepts presented in course. Presentations and exchanges between students and professors will conclude this second part. All these notions will be applied with the realization of a major project, together with the implementation of a complete development environment.

IS_3450 Conferences (Lectures: 10h / Tutorial classes: -h / Lab: -h)
The lectures are delivered by professionals of the field. The themes vary from one year to the next depending on the evolution of techniques.

SH_3EME Humanities (5 ECTS)

DSH_3000 Responsible and sustainable management of human resources in a complex environment

(Lectures: 16h / Tutorial classes: 6h / Lab: -h)

The course presents the evolution of organizations in a complex environment (team management, corporate culture in a multicultural context, professional project through the dynamics and management of evolutions). It emphasizes the strategic role of human resources management in a CSR context (Quality of Life at Work - OHS) in order to prepare engineering students (guided by the 26000 standard) for their role as project managers, project leaders or employees of a project team.

It introduces the notions of labor law that are essential for engineers (employment contracts, expatriation, work environment in the company) by integrating the social and societal concerns of the company.

The practical courses allow, through an edutainment approach (or in the form of a serious game):

- to implement an HRM that values responsibility and ethics (Remuneration, Training, Skills management, Health and Safety at work).
- Identify good practices to implement a CSR policy.

DSH_3060 English (Lectures: -h / Tutorial classes: 24h / Lab: -h)

The objective of the third-year courses is to make the students able to work in English and have a good command of the language.

The goal is achieving a professional use and to reach, at least, a B2 level requested do obtain the degree.

Two third-year options are grouped together for English courses. Level groups can be formed. The students will be able to work on different aspects of life professional (communication in different settings, in the office, abroad, in seminars, through writing, orally, case studies...), by carrying out work groups and putting in practice the knowledge they have acquired throughout their training.

DSH_3061 FLE (French for foreigners) (Lectures: -h / Tutorial classes: 24h / Lab: -h)

The main goal of this class is training the foreign students through communication fundamentals for everyday life, proposing them an introduction to French culture and civilization and more advanced knowledge in order to work in a French company during the final internship period.

ENSEA

Beyond Engineering

Control and Power Engineering

Graduate/Master Program

ENSEA – Semester 9 AEI - French-Taught

Edition 2023

Control and Power Engineering
ENSEA - AEI 3rd Year Academic Track

Level	**Second year of Master's Degree/Graduate/Semester 9**		
Period	Fall semester (September to January)		
Language of tuition	French		
ECTS	30		
Courses	Code	Course	ECTS
	AEI_1	**Energy [Composed of:]**	**5**
	AEI_3105	Renewable Energy	
	AEI_3110	Inverters and power quality	
	AEI_2	**Automation and Diagnosis [Composed of:]**	**5**
	AEI_3104	Non-linear Automation	
	AEI_3151	Diagnosis	
	AEI_3154	Advanced Automation Lab	
	AEI_3	**Identification and Control [Composed of]**	**4**
	AEI_3150	Acquisition Systems	
	AEI_3153	Transverse project: Acquisition	
	AEI_3102	Artificial Intelligence for System Control	
	AEI_4	**Actuators [Composed of:]**	**5**
	AEI_3111	Electrical actuators	
	AEI_3121	Direct digital control of devices	
	AEI_5	**Project [Composed of:]**	**6**
	AEI_3139	Project	
	AEI_3152	Electromagnetic Compatibility	
	AEI_3140	Conferences	
	SH-3EME	**Humanities [Composed of:]**	**5**
	DSH_3000	Responsible and sustainable management of human resources in a complex environment	
	DSH_3060	English	
	DSH_3061	FLE (French for foreigners) or Spanish or German	

Control and Power Engineering
ENSEA - AEI 3rd Year Academic Track

AEI_1 Energy (5 ECTS)

AEI_3105 Renewable Energy (Lectures: 10h / Tutorial classes: 8h / Lab: 4h)
The aim of this academic module is to present the economic and technological challenges related to the development of these energy sources use as well as their impact in a "sustainable development" approach.
The main points to be explored will be :
- the different forms of RE and their exploitation
- the technological structures used
- links to the existing electricity network
- environmental and economic impact

AEI_3110 Inverters and power quality (Lectures: 18h / Tutorial classes: 12h / Lab: 12h)
The objective of this course is to introduce the fundamental notions for understanding the functioning of an inverter and its reaction depending on its load and of its power supply network. This training allows to deepen students' understanding of the power components used in energy conversion systems through the particular study of some of them.
- Recap on the operation of alternating current motor – Couple and Speed characteristics. Principles of speed variation.
- Power components, MOS transistor.
- Single-phase and three-phase inverters: principles of MLI and full-wave operation.
- Harmonic study of the output of the inverter.
- Reversibility of the inverter. Application to PWM rectifiers with sinusoidal current absorption.
- Multi-level converters. HVDC link.

AEI_2 Automation and Diagnosis (5 ECTS)

AEI_3104 Non-linear Automation (Lectures: 12h / Tutorial classes: 10h / Lab: -h)
This course is an introduction to control and observation of non-linear systems. It is introduced by a few basic theoretical concepts (controllability, observability, linearity, stability...). Then, control laws and observers are introduced. In order to illustrate the interest off the presented concepts and solutions, a practical application will be proposed with the example of an asynchronous machine control.
- Geometrical approach: change of reference frame, linearization, decoupling, zero dynamics.
- Stability and stabilization: Lyapunov, LaSalle.
- Singular disturbances: invariant variety, reduction model.
- Sliding mode controls and observers.
- Typical examples: electrical engineering, aeronautics, ...

AEI_3151 Diagnosis (Lectures: 8h / Tutorial classes: 8h / Lab: -h)
Diagnosis consists in detecting, locating and, mor generally, determining the characteristics of anomalies occurring in a system. The objective of this course is to present the principles of diagnosis based on the models and the main approaches in order to generate indicators of defects (residuals) and build a decision. The focus will be on conditions for the use of various tools in order to come up with a global diagnosis strategy.
- Structural analysis of a system: causal analysis, sensor placement.
- Generation of residues: observers.
- Inversion to the left.
- Decision for diagnosis: tests, logic and diagnosis, classification.
- Overall diagnostic strategy: functioning/malfunctioning oriented approaches and active control authorizing errors.

AEI_3154 Advanced Automation Lab (Lectures: -h / Tutorial classes: -h / Lab: 16h)
This module aims at putting into practice the main notions of automation explored through different courses of the general study track: identification and parametric estimation, space
status, interference rejection, optimal control, error detection and localization, control and non-linear observers, etc....

AEI_3 Identification and Control (4 ECTS)

AEI_3150 Advanced Identification and Control (Lectures: 12h / Tutorial classes: 8h / Lab: -h)
The aim of this course is to show how the optimization techniques have an application in automation, in particular through the identification of models (estimation of parameters) and commands based on the optimization of criteria.
- Non-parametric and parametric identification methods.
- Graphic or deterministic methods: methods of Strejc and Broida, open and closed loop system, non-scalable and scalable systems, oscillatory response system.
- Statistical methods: gradient criterion, least squares, recursive least squares, Kalman filter.
- Optimum control: optimization without and with constraints on the status and control with fixed limits, and variables: methods of variation, principle of minimum.
- General problem of the prosecution and the optimal regulator.

AEI_3153 Multivariable linear control (Lectures: 10h / Tutorial classes: 6h / Lab: 4h)
This course introduces the main concepts in order to study the control of multivariable systems (several actuators, several sensors), based on a representation-type modelling of state. This course extends the notions of state space as seen in the first-year multivariate cases course, and raises and explains the notions of rejection of disturbances and robustness.
- Continuous and sampled linear state representation,
- Relative degrees and Brunowsky's form,
- Multivariable pole placement algorithm,
- Application to control by status feedback with observer,
- Notions of disturbance rejection and robustness.

AEI_3102 Artificial Intelligence for System Control (Lectures: 8h / Tutorial classes: 8h / Lab: 8h)
This course presents the application of Artificial Intelligence techniques to control systems. It is structured in two main parts and a complement:
- Fuzzy control: Fuzzy logic (sets, operators, terminology), fuzzy controller (fuzzyfication, inference, defuzzyfication), Sugeno and Mandani structures, industrial applications, hardware and software aspects.
- Neuronal networks: biological neurons, formal model, multi-layered perceptron, deep architectures, introduction to statistical learning.
- Identification of processes by neural models, regulator copying, neural models for adaptive control and dynamic control.

AEI_4 Actuators (5 ECTS)

AEI_3111 Electrical actuators (Lectures: 16h / Tutorial classes: 12h / Lab: 8h)
The objective of this course is to formalize the design of transducers of mechanical energy, and more specifically as observed in direct and alternating current electrical machines, associated with their static converter.
- Electromechanical energy conversion.
- Permanent magnets.
- General equations of electrical machines.
- Direct current machines: servo-motors, transient state.
- Synchronous and asynchronous alternating current machines.
- Stepper motors, variable reluctance motors.
- Scalar and vector control algorithms.
- Control devices: association with the static converter.

AEI_3121 Direct digital control of devices (Lectures: 8h / Tutorial classes: 8h / Lab: 32h)
This training focuses on the design of microcontroller-based systems, both hardware and software. The application in control-related areas is naturally put in evidence. The Lab is presented in the form of a mini project, where a complete system will be designed.
- Microcontroller-based systems: design, development, choices, languages (C, assembler);
- Presentation of the different kinds of microcontrollers;
- Presentation of a signal processing processor;
- Study of a direct numerical control of an electric actuator by DSP;
- Principle of determination of digital correctors.

AEI_5 Project (6 ECTS)

AEI_3139 Project (Lectures: -h / Tutorial classes: -h / Lab: 56h)
Students must design, study and then carry out completely a control process, control in general or any other aspect related to the teachings of the AEI track. They are supervised and advised by several teachers sometimes in collaboration with companies.

AEI_3152 Electromagnetic Compatibility (Lectures: 4h / Tutorial classes: 4h / Lab: -h)
The objective is to make the students aware of the practical aspects involved in complying with EMC standards in the design of power electronic devices and in their control. This module therefore aims to complete the second-year module, with a focus on the areas specific to the AEI track.

AEI_3140 Conferences (Lectures: 10h / Tutorial classes: -h / Lab: -h)
The lectures are delivered by professionals of the field. Topics covered may vary from one year to the other, the following topics are only a sample of possible subjects. Vector control of asynchronous machines, electric traction, robust control, adaptive control (Kalman filtering).

SH_3EME Humanities (5 ECTS)

DSH_3000 Responsible and sustainable management of human resources in a complex environment

(Lectures: 16h / Tutorial classes: 6h / Lab: -h)

The course presents the evolution of organizations in a complex environment (team management, corporate culture in a multicultural context, professional project through the dynamics and management of evolutions). It emphasizes the strategic role of human resources management in a CSR context (Quality of Life at Work - OHS) in order to prepare engineering students (guided by the 26000 standard) for their role as project managers, project leaders or employees of a project team.

It introduces the notions of labor law that are essential for engineers (employment contracts, expatriation, work environment in the company) by integrating the social and societal concerns of the company.

The practical courses allow, through an edutainment approach (or in the form of a serious game):

- to implement an HRM that values responsibility and ethics (Remuneration, Training, Skills management, Health and Safety at work).
- Identify good practices to implement a CSR policy.

DSH_3060 English (Lectures: -h / Tutorial classes: 24h / Lab: -h)

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The goal is achieving a professional use and to reach, at least, a B2 level requested do obtain the degree.

Two third-year options are grouped together for English courses. Level groups can be formed. The students will be able to work on different aspects of life professional (communication in different settings, in the office, abroad, in seminars, through writing, orally, case studies...), by carrying out work groups and putting in practice the knowledge they have acquired throughout their training.

DSH_3061 FLE (French for foreigners) (Lectures: -h / Tutorial classes: 24h / Lab: -h)

The main goal of this class is training the foreign students through communication fundamentals for everyday life, proposing them an introduction to French culture and civilization and more advanced knowledge in order to work in a French company during the final internship period.

ENSEA

Beyond Engineering

Embedded Systems

Graduate/Master Program

ENSEA – Semester 9 ESE - French-Taught

Edition 2022

Embedded Systems
ENSEA - ESE 3rd Year Academic Track

Level	**Second year of Master's Degree/Graduate/Semester 9**		
Period	Fall semester (September to January)		
Language of tuition	French		
ECTS	30		
Courses	Code	Course	ECTS
	ESE_1	**Microcontrollers [Composed of:]**	**5**
	ESE_3720	Microcontroller systems	
	ESE_2	**Real-time Kernel [Composed of]**	**5**
	ESE_3735	Real-time Kernel	
	ESE_3	**Sensors and Actuators [Composed of:]**	**5**
	ESE_3710	Sensors and conditioning	
	ESE_3745	Actuators and applied automation	
	ESE_3760	Sensors and Networks Lab	
	ESE_4	**Fundamental techniques for embedded systems [Composed of:]**	**5**
	ESE_3740	Advanced digital processing	
	ESE_3750	EMC, radiation hardening and reliability	
	ESE_3727	Industrial Networks and Buses	
	ESE_5	**Advanced Electronic Systems [Composed of:]**	**5**
	ESE_3770	Conferences	
	ESE_3737	Embedded Linux	
	ESE_3771	Introduction to Robotics	
	ESE_3756	Electronic systems for the automotive industry	
	SH-3EME	**Humanities [Composed of:]**	**5**
	DSH_3000	Responsible and sustainable management of human resources in a complex environment	
	DSH_3060	English	
	DSH_3061	FLE (French for foreigners) or Spanish or German	

Embedded Systems
ENSEA - ESE 3rd Year Academic Track

ESE_1 Microcontrollers (5 ECTS)

ESE_3720 Microcontroller systems (Lectures: 14h / Tutorial classes: 10h / Lab: 28h)

At the end of this course, students will be able to design a microcontroller or DSP-based system, both hardware and software. The lab consists in developing a complete system, such as the interfacing of a SPI inclinometer on CAN network.

- Processor architecture. CISC, RISC, DSP, pipeline.
- Design of an embedded system based on a microcontroller. Memory plan, address decoding, device controller, device management (waiting loop, interruption and DMA).
- Memories. Memory hierarchy, the different types of memory, volatile and non-volatile memory technology, cache operation, virtual memory (MMU).
- 32-bit microcontrollers. Blackfin architecture, interruptions, SPI bus, DMA, memory management, study of a digital filter for audio.
- ARM processors. Kinds of ARM processors, description of a CortexA9, programming model, calculation unit (NEON), trustzone, presentation of the SABRE Lite board based on the iMX6Q microcontroller from Freescale.
- Operation of multi-core processors.

ESE_2 Real-time Kernel (5 ECTS)

ESE_3735 Real-time Kernel (Lectures: 10h / Tutorial classes: 4h / Lab: 40h)
This course presents the principles and implementation of the real-time kernels in an embedded environment. The multitasking concepts (task objects, semaphores, mail boxes, etc.) and the input-output mechanisms (interruptions, drivers) are presented in the context of a real-time operating system (VxWorks), and illustrated through examples and hands-on sessions.
The multiprocessor aspect will be presented and illustrated with manipulations on multi DSP systems. Different technologies are presented and compared (time cores, time kernels, real time UNIX, Linux).
- Multitasking systems. Notion of task, allocation tasks, communication between tasks, synchronization, multitasking kernels, interruptions, I/O.
- Implementation on a Sabre Lite board based on a CortexA9.

ESE_3 Sensors and Actuators (5 ECTS)

ESE_3710 Sensors and conditioning (Lectures: 14h / Tutorial classes: 10h / Lab: -h)
The objective of this course is the design of a measurement chain from the sensor to the analog to digital convertor. The use and parameterization of an integrated sensor are part of this training.
- Measurement chains. The different elements of a measurement chain, characteristics, accuracy of a chain of measurement.
- Instrumentation and isolation amplifiers. Objectives and realization, common mode rejection, guard circuit, technological choices.
- Design of a measurement chain. Calculation of signal-to-noise, filtering, choice of analog to digital converter, effective resolution.
- Sensors for temperature, deformation, force and pressure.
- Accelerometers. Operating principle of acceleration sensors, characteristics, applications.
- Study of an integrated sensor.

ESE_3745 Actuators and applied automation (Lectures: 10h / Tutorial classes: 4h / Lab: 12h)
The objective of this course is to present in a functional way the different types of electric actuators that can be used in industrial embedded applications. Without proposing a detailed and structural study of it, the different families of actuators are presented with their associated command, then some examples will be studied.
- The different types of electrical machines (direct current, alternative, stepper, etc.).
- The main associated sensors: current measurements, speed, position, couple.
- Modelling of electric actuators: assemblies formed of the machine, its feeding device (static energy converter), associated sensors and command.
- The command laws used: direct orders or servo drives, analogue commands or sampled, performance obtained.
- The practical work will allow to implement some control laws studied on conventional actuators, based on a direct or alternative current motor.

ESE_3760 Sensors and Networks Lab (Lectures: -h / Tutorial classes: -h / Lab: 20h)
This module includes three practical exercises: a first one on the instrumentation amplifier and on the dimensioning of a noise filter in relation to an analogue-to-digital converter, the second on the CAN network and a third, in three sessions, on the programming of a network socket, within the framework of the realization of a connected device under Linux.

ESE_4 Fundamental techniques for embedded systems (5 ECTS)

ESE_3740 Advanced digital processing (Lectures: 18h / Tutorial classes: 8h / Lab: 12h)

This course focuses on the design and implementation of digital processing in embedded systems. It presents the techniques of filter synthesis with constraints, the modeling of multi-cadence, with an emphasis on the consequences of the effects due to quantification and finite precision of the calculations. Fast processing techniques are presented and illustrated with manipulations. The focus is put on specific architectures offered by specialized processors (DSP), and their implications for the design of systems.

- Synthesis of digital filters. Recursive and non-recursive filters, multi-cadence filtering, filter banks.
- Structure and realization of filters. Number coding, quantization noise modeling, computational noise, Sigma Delta conversion.
- Fast transform and applications. Processing by blocks, fast Fourier transform algorithms, fast convolution algorithm.
- Exploitation of the architecture of a DSP.

ESE_3750 EMC, radiation hardening and reliability (Lectures: 16h / Tutorial classes: -h / Lab: -h)

The objective of this course is to know how to take EMC into account from the very beginning of an embedded system's design.

ESE_3727 Industrial Networks and Buses (Lectures: 8h / Tutorial classes: 4h / Lab: -h)

The objective of this course is to study buses and networks allowing systems to communicate. The main buses and networks are presented: Ethernet, WiFi, CAN, FlexRay, not to mention the software dimension.

- Networks. OSI layered model, function of different layers, comparison with the structure of a TCP/IP stack,
- layers 1 and 2: the main standards (Ethernet, WiFi, PPP), layers 3 and 4: IPv4, associated protocols (TCP, UDP, ICMP, ARP/RARP, IGMP), routing and DNS, top layers: overview of tools (ping, netstat) and common applications (telnet, FTP, SMTP, http, ...), introduction to security and hacking issues.
- Field networks. I2C bus, Profibus, CAN networks and LIN, FlexRay.
- Software access. Sockets and their use, stacks of communication.

ESE_5 Advanced Electronic Systems (5 ECTS)

ESE_3737 Embedded Linux (Lectures: 12h / Tutorial classes: 2h / Lab: 24h)
This course presents the architecture of Linux, with a double focus on the user vision and the kernel vision. At the end of this course and of the associated practical exercises, students will know how to configure and parameterize a kernel, how to
build a file system and how to export the whole conception on a hardware target. They will have the sufficient notions to manage interruptions, create new peripherals, develop drivers and multi-process applications. This course is intended for students with
basic knowledge of microprocessor architecture, real-time kernels (tasks and communication intertasking) and device drivers.
- Development of a multi-process application under Linux. The life cycle of processes, threads, demons, scheduler, inter-process communication: signals, semaphores and Posix message queues, hardware protection by MMU, memory management, communication by shared memory, communication by tubes.
- Generation of an embedded Linux system. The "bootstrap loader" (Uboot), the boot steps, the init process, use of a disk in memory, use of NFS, kernel configuration, creation of a file system, memory management, development methods, and debugging.
- Development of a driver under Linux. Notion of modules, driver architecture, interruptions, synchronization, memory management in the kernel, management of time in the kernel, peripheral model.

ESE_3756 Electronic systems for the automotive industry (Lectures: 12h / Tutorial classes: 4h / Lab: -h)
This course consists in studying some embedded systems in the automobile industry, by considering first the global functional aspect, then by looking at one or more parts of the system to illustrate the lessons learned from this study track.

ESE_3771 Introduction to Robotics (Lectures: 2h / Tutorial classes: -h / Lab: 20h)
Through a robotics challenge, the objective of this course is to learn how to control a mobile robot using neural networks.- Implementation of specific sensors (Odometer, luminosity, colors, rangefinder).- Control of a Braitenberg vehicle by neural networks.- Data fusion using a complementary filter or Kalmann.

ESE_3770 Conferences (Lectures: 10h / Tutorial classes: -h / Lab: -h)
These conferences allow the students to discover some industrial applications, with themes varying from one year to the next.

SH_3EME Humanities (5 ECTS)

DSH_3000 Responsible and sustainable management of human resources in a complex environment

(Lectures: 16h / Tutorial classes: 6h / Lab: -h)

The course presents the evolution of organizations in a complex environment (team management, corporate culture in a multicultural context, professional project through the dynamics and management of evolutions). It emphasizes the strategic role of human resources management in a CSR context (Quality of Life at Work - OHS) in order to prepare engineering students (guided by the 26000 standard) for their role as project managers, project leaders or employees of a project team.

It introduces the notions of labor law that are essential for engineers (employment contracts, expatriation, work environment in the company) by integrating the social and societal concerns of the company.

The practical courses allow, through an edutainment approach (or in the form of a serious game):

- to implement an HRM that values responsibility and ethics (Remuneration, Training, Skills management, Health and Safety at work).
- Identify good practices to implement a CSR policy.

DSH_3060 English (Lectures: -h / Tutorial classes: 24h / Lab: -h)

The objective of the third-year courses is to make the students able to work in English and have a good command of the language.

The goal is achieving a professional use and to reach, at least, a B2 level requested do obtain the degree.

Two third-year options are grouped together for English courses. Level groups can be formed. The students will be able to work on different aspects of life professional (communication in different settings, in the office, abroad, in seminars, through writing, orally, case studies...), by carrying out work groups and putting in practice the knowledge they have acquired throughout their training.

DSH_3061 FLE (French for foreigners) (Lectures: -h / Tutorial classes: 24h / Lab: -h)

The main goal of this class is training the foreign students through communication fundamentals for everyday life, proposing them an introduction to French culture and civilization and more advanced knowledge in order to work in a French company during the final internship period.

ENSEA

Beyond Engineering

Mechatronics

Graduate/Master Program

ENSEA – Semester 9 MSC - French-Taught

Edition 2023

Mechatronics
ENSEA - MSC 3rd Year Academic Track

Level	**Second year of Master's Degree/Graduate/Semester 9**		
Period	Fall semester (September to January)		
Language of tuition	French		
ECTS	30		
Courses	Code	Course	ECTS
	MSC_1	**Mechatronic systems control [Composed of:]**	**6**
	MSC_3805	Acquisition and control systems	
	MSC_3812	Digital control of actuators	
	MSC_2	**Embedded systems for mechatronics [Composed of:]**	**6**
	MSC_3809	Electromagnetic compatibility	
	MSC_3807	Bus and Network	
	MSC_3810	Sensors and measurement chain	
	MSC_3806	Real-time kernel	
	MSC_3	**Design and dimensioning of mechanical systems [Composed of]**	**4**
	MSC_3802	Design and dimensioning of mechanical systems	
	MSC_4	**Robotics [Composed of:]**	**4**
	MSC_3851	Robotics	
	MSC_5	**Project [Composed of:]**	**5**
	MSC_3837	Mini Project	
	MSC_3850	Conferences	
	SH-3EME	**Humanities [Composed of:]**	**5**
	DSH_3000	Responsible and sustainable management of human resources in a complex environment	
	DSH_3060	English	
	DSH_3061	FLE (French for foreigners) or Spanish or German	

Mechatronics
ENSEA - MSC 3rd Year Academic Track

MSC_1 Mechatronic systems control (6 ECTS)

MSC_3805 Acquisition and control systems (Lectures: 10h / Tutorial classes: 10h / Lab: 28h)

This course provides knowledge in microcontroller-based system design associated with an electric actuator for digital control.
- Microcontroller-based systems. Choice, design, development, C language
- Study of a STM32 microcontroller and its peripherals (UART, DMA, Timer, PWM, Encoder interface, ADC).
- Different types of electrical machines.
- Modelling of electric actuators.
- Study of a direct digital control system of electric actuators with STM32 microcontroller

MSC_3812 Digital control of actuators (Lectures: 12h / Tutorial classes: 8h / Lab: 12h)
This course aims at studying the modelling and digital control of dynamic systems, in order to provide the theoretical and practical basis for the development and implementation of algorithms for control and observation in a sampled context.
- Dynamic modeling, linearization of a representation of non-linear state.
- Sampling and z-transformation for digital control. Specifications.
- Synthesis of digital correctors (PID, RST, Smith's Predictor, ...) and structuring of the patterns of control.
- Control by state feedback and observer (Luenberger) : continuous and sampled linear state representation, controllability, observability, pole placement.
The Labs are focused on the identification of models (SBPA, least-squares), dynamic systems modelling, automatic code generation (fast prototyping with a DSP target) applied to motor control.

MSC_2 Embedded systems for mechatronics (6 ECTS)

MSC_3809 Electromagnetic compatibility (Lectures: 8h / Tutorial classes: -h / Lab: -h)
The aim is to make students aware of the practical aspects involved in complying with EMC standards on the design of power electronics devices and of their control. This module therefore aims to complement the EMC basics, with a focus on applications specific to Mechatronics.

MSC_3807 Bus and Network (Lectures: 6h / Tutorial classes: -h / Lab: 4h)
The aim of this course is to study the connections allowing systems to communicate. This is not an exhaustive description of the different links, but a presentation of the basic concepts through some examples, such as the CAN network for a fieldbus.
- Token ring, Profibus, Modbus.
- Fieldbus, I2C bus, CAN, LIN networks, MOST, FlexRay, application examples.

MSC_3810 Sensors and measurement chain (Lectures: 12h / Tutorial classes: 12h / Lab: 16h)
The objective of this course is the design of a chain of measurement, from the sensor to the analog to digital converter.
- Measurement chains. The different elements of a measurement chain, characteristics, accuracy of a chain measurement.
- Study of some sensors. Temperature sensors, deformation, force, pressure, speed, acceleration.
- The instrumentation and isolation amplifier. Objectives and realization, common mode rejection, circuits, technological choices.
- Analog to digital conversion. The different types of converters, characteristics, choice of CAN.

MSC_3806 Real-time kernel (Lectures: 12h / Tutorial classes: 4h / Lab: 20h)
This course introduces the principles and implementation of the real-time kernels. Multitasking concepts (objects tasks, semaphores, mailboxes) and input - output mechanisms (interruptions, drivers) are presented within the framework of a real-time operating system (FreeRTOS), and illustrated with examples and sessions of practical work.
- Multitasking systems. Notion of task, allocation of tasks, communication between tasks, synchronization, multitasking cores, interrupts, input-output.
- Implementation on microprocessor platform or DSP.

MSC_3 Design and dimensioning of mechanical systems (4 ECTS)

MSC_3802 Design and dimensioning of mechanical systems (Lectures: 4h / Tutorial classes: 4h / Lab: 48h)

The objective of this module is to explore the different aspects of mechanical design based on a concrete study (for example, the accessory relay for an aircraft engine). This example serves as a guideline and support, throughout the project. Students must therefore create and deliver results at regular intervals:

- Technical documentation justifying the topological choices and technologies selected, SolidWorks model ...
- Functional analysis (Engineering Methodology System, based on the SysML language)
- Kinematic analysis and mechanism theory
- Static study
- Strength of materials
- Sizing of the pivot connections (bearings), the drive shafts (bending-twisting) and key
- Standardized geometry and dimensioning of gears
- Modeling of the system using CAD software (SolidWorks)

MSC_4 Robotics (4 ECTS)

MSC_3851 Robotics (Lectures: 12h / Tutorial classes: 16h / Lab: 20h)
The objectives of this course are to model robotic systems in order to control them. The aim is to provide the theoretical and practical bases necessary for the design and use of industrial robots

- Classification of architectures (serial, parallel)
- Configuration of robots with the objective of their modeling, homogeneous coordinates
- Geometric, kinematic and dynamic models, direct and reverse
- Use of the Modelica language for modeling and simulating real robots with Simscape or OpenModelica.

MSC_ 5 Project (5 ECTS)

MSC_3837 Mini Project (Lectures: -h / Tutorial classes: -h / Lab: 44h)
The objective of this project is to design a system or a part of a mechatronic system, with the application of the theoretical or practical knowledge acquired during the year: quadcopter, drone, robot...

MSC_3850 Conferences (Lectures: 10h / Tutorial classes: h / Lab: h)
The lectures are delivered by engineers or researchers working in the different specialties of the option: mechatronics, system engineering... Topics may vary from one year to the next.
The following are only a sample of possible subjects: avionics, robotics, systems engineering applied to the automotive or space industry...

SH_3EME Humanities (5 ECTS)

DSH_3000 Responsible and sustainable management of human resources in a complex environment

(Lectures: 16h / Tutorial classes: 6h / Lab: -h)

The course presents the evolution of organizations in a complex environment (team management, corporate culture in a multicultural context, professional project through the dynamics and management of evolutions). It emphasizes the strategic role of human resources management in a CSR context (Quality of Life at Work - OHS) in order to prepare engineering students (guided by the 26000 standard) for their role as project managers, project leaders or employees of a project team.

It introduces the notions of labor law that are essential for engineers (employment contracts, expatriation, work environment in the company) by integrating the social and societal concerns of the company.

The practical courses allow, through an edutainment approach (or in the form of a serious game):

- to implement an HRM that values responsibility and ethics (Remuneration, Training, Skills management, Health and Safety at work).
- Identify good practices to implement a CSR policy.

DSH_3060 English (Lectures: -h / Tutorial classes: 24h / Lab: -h)

The objective of the third-year courses is to make the students able to work in English and have a good command of the language.

The goal is achieving a professional use and to reach, at least, a B2 level requested do obtain the degree.

Two third-year options are grouped together for English courses. Level groups can be formed. The students will be able to work on different aspects of life professional (communication in different settings, in the office, abroad, in seminars, through writing, orally, case studies...), by carrying out work groups and putting in practice the knowledge they have acquired throughout their training.

DSH_3061 FLE (French for foreigners) (Lectures: -h / Tutorial classes: 24h / Lab: -h)

The main goal of this class is training the foreign students through communication fundamentals for everyday life, proposing them an introduction to French culture and civilization and more advanced knowledge in order to work in a French company during the final internship period.

ENSEA

Beyond Engineering

Networks, Telecommunications & Security

Graduate/Master Program

ENSEA – Semester 9 RT - English-Taught

Edition 2023

Networks, Telecommunications & Security
ENSEA - RTS 3rd Year Academic Track

Level	**Second year of Master's Degree/Graduate/Semester 9**		
Period	Fall semester (September to January)		
Language of tuition	English		
ECTS	30		
Courses	Code	Course	ECTS
	RTS_1	**Digital communications principles [Composed of:]**	**5**
	RTS_3500	Digital Telecommunications	
	RTS_2	**Wireless communications [Composed of:]**	**4**
	RTS_3535	Wireless communications	
	RTS_3	**Networks [Composed of]**	**6**
	RTS_3536	Network Protocols	
	RTS_3534	Network interconnection	
	RTS_3521	Java for Networks	
	RTS_4	**Security [Composed of:]**	**5**
	RTS_3529	Architecture of Information Systems	
	RTS_3533	Software security	
	RTS_3532	Network Security	
	RTS_5	**Project [Composed of:]**	**5**
	RTS_3549	Networks and Telecommunications Lab	
	RTS_3550	Conferences	
	SH-3EME	**Humanities [Composed of:]**	**5**
	DSH_3000	Responsible and sustainable management of human resources in a complex environment	
	DSH_3060	English	
	DSH_3061	FLE (French for foreigners) or Spanish or German	

Networks, Telecommunications & Security
ENSEA - RTS 3rd Year Academic Track

RTS_1 Digital communications principles (5 ECTS)

RTS_3500 Digital Telecommunications (Lectures: 24h / Tutorial classes: 20h / Lab: 24h)

This course is designed to introduce the concepts of modern digital communications, which are the basis for impressive increases in the information transmission and in the quality of transmissions on wireless networks (WiFi, 4G, 5G, BlueTooth, etc.). This course is based on the knowledge acquired in the second year in Digital Communications (Minor Signal).

The practical labs, which use the Matlab software for matrix calculation, will allow to deepen the theoretical concepts and to apply them in a system of concrete communication. After reminding the benefits of digital communications in relation to analogue communications, we will study in detail the aspects that have contributed to the development of new
information and communication technologies.

The following points will be explored:

- very high-speed communications, high spectral efficiency, constellation diagrams;
- wireless channel modeling (mobile radio), levelling techniques;
- OFDM multi-carrier communications;
- error-correcting coding: convolutional codes and decoders, introduction to Turbo-codes and associated LDPC codes.

RTS_2 Wireless communications (4 ECTS)

RTS_3535 Wireless communications (Lectures: 24h / Tutorial classes: 12h / Lab: 26h)

In this course the high-speed transmission techniques and multiple access used in the current standards are presented. The first part is focused on the parameterization of the physical layer of these systems (useful flow rates, symbolic flow rate, code output…). In the second part, several techniques are presented in order to improve the performance of
layer-level access of wireless telecommunications. Practical work in Matlab allows to study the performance of multi-antenna systems, power allocation techniques and retransmissions.

- Wireless channels (Rayleigh model). Capacity of wireless channels and cut-off probability.
- Power allocation: waterfilling
- ML detection, design of ML detection systems for wireless communication
- Spectrum widening techniques, frequency gaps, CDMA
- MIMO systems: diversity techniques at reception and emission, Alamouti code, techniques of spatial multiplexing.
- MIMO-OFDM systems. Ex: DVB-T and ADSL. Analysis of WiFi (802.11.a/g/n) and 4G (LTE) systems.
- Multiple access in OFDM.
- Acknowledgement and retransmissions (ACK/NACK, ARQ, Hybrid-ARQ). Application: HSDPA
- Medium access and collision (ALOHA, CSMA).

Application: Wifi

- Frequency reuse in cellular systems.

Application: GSM, LTE.

RTS_3 Networks (6 ECTS)

RTS_3536 Network Protocols (Lectures: 8h / Tutorial classes: 10h / Lab: 12h)
The objective of this course is to train engineering students to design applications based on a data transmission network. Although mainly based on TCP IP protocols, other protocols will also be studied. The content of this course covers the analysis of the different protocols. Finally, an introduction to the architecture of network services will conclude the course.
- General concepts and main characteristics of communication protocols.
- OSI reference model. Protocols standardization.
- Local networks. Access methods, static/dynamic allocation, centralized/decentralized management.
- CSMA/CD, token techniques.
- TCP/IP-Internet protocol stack.
- Architecture definition and dimensioning. Model of Erlang for circuit-switched networks, model of queues for packet-switched networks.
- Real-time protocols. Application to voice over IP (RTP).
- Client/server architectures. 3-tier architecture,
N-tier architecture.
Laboratory analysis of network protocol under IP.

RTS_3534 Network Interconnection (Lectures: 14h / Tutorial classes: 6h / Lab: 24h)
- The notions of IP addressing and sub-addressing
- The creation of an IP addressing plan
- Definition of architecture
- Routing protocols: RIP, OSPF, BGP, MPLS
- Congestion control, TCP Tahoe, TCP Reno
- Quality of service
- Software defined networking

RTS_3521 Java for Networks (Lectures: 4h / Tutorial classes: -h / Lab: 24h)
This training is designed as an extension of Second-year Java course. More specifically, it deals with the creation of network services in Java using specific packages for networks. The creation and use of sockets is fundamental in this course.
- Recap on Java: operators, operator overloading and functions, classes, builders and destroyers, inheritance and interfaces.
- Client-server applications on UDP
- Client-server applications over multi-threaded TCP

RTS_4 Network architecture and security (5 ECTS)

RTS_3529 Architecture of Information Systems (Lectures: 6h / Tutorial classes: 2h / Lab: 24h)
The aim of the course is to understand the key elements of a telecommunication information system, its architecture and its implementation model:
- Role of the information system (IS)
- The interfaces of the telecommunication network with the IS and the data exchanged,
- Steps in defining an IS architecture, stages of implementation (TOGAF method). Model Publisher/Integrator
- Operational processes and concepts (ITU M.3050, eTOM)
- SOA Applications and Architecture
- Cases of functional treatment of information: activation, maintenance and invoicing of service.
Application for corporate VPN networks, FTTH and Mobile.

RTS_3532 Network Security (Lectures: 16h / Tutorial classes: 2h / Lab: 12h)
- Economic vulnerabilities and challenges.
- Communications security, encryption.
- Flow control: firewall.
- Detection of network attacks.
- Implementing and testing a firewall on a network platform.

RTS_3533 Software Security (Lectures: 4h / Tutorial classes: 2h / Lab: 8h)

RTS_5 Project (5 ECTS)

RTS_3549 Networks and Telecommunications Lab (Lectures: -h / Tutorial classes: -h / Lab: 40h)
Each student will deal with a theme of his or her choice, either on the field of "telecommunications", or in the field of "networks" (high-speed coding techniques, distributed storage, Massive MIMO, network virtualization, VPN solutions, streaming applications, sensor networks, IoT platforms, software radio...) The objective is to obtain a functional demonstrator.

RTS_3550 Conferences (Lectures: 10h / Tutorial classes: -h / Lab: -h)
The lectures are delivered by professionals working in this specialty field and are focused on current issues. The topics may vary from one year to the next depending on the evolution of the techniques.
- Free Internet, dematerialization of environments and connected objects, what impact on telecommunication companies? (PSA Group)
- Corporate network architectures (data, voice and data services, security) and their developments (PSA Group)
- The challenges of 5G (National Frequency Agency)

SH_3EME Humanities (5 ECTS)

DSH_3000 Responsible and sustainable management of human resources in a complex environment

(Lectures: 16h / Tutorial classes: 6h / Lab: -h)

The course presents the evolution of organizations in a complex environment (team management, corporate culture in a multicultural context, professional project through the dynamics and management of evolutions). It emphasizes the strategic role of human resources management in a CSR context (Quality of Life at Work - OHS) in order to prepare engineering students (guided by the 26000 standard) for their role as project managers, project leaders or employees of a project team.

It introduces the notions of labor law that are essential for engineers (employment contracts, expatriation, work environment in the company) by integrating the social and societal concerns of the company.

The practical courses allow, through an edutainment approach (or in the form of a serious game):

- to implement an HRM that values responsibility and ethics (Remuneration, Training, Skills management, Health and Safety at work).
- Identify good practices to implement a CSR policy.

DSH_3060 English (Lectures: -h / Tutorial classes: 24h / Lab: -h)

The objective of the third-year courses is to make the students able to work in English and have a good command of the language.

The goal is achieving a professional use and to reach, at least, a B2 level requested do obtain the degree.

Two third-year options are grouped together for English courses. Level groups can be formed. The students will be able to work on different aspects of life professional (communication in different settings, in the office, abroad, in seminars, through writing, orally, case studies...), by carrying out work groups and putting in practice the knowledge they have acquired throughout their training.

DSH_3061 FLE (French for foreigners) (Lectures: -h / Tutorial classes: 24h / Lab: -h)

The main goal of this class is training the foreign students through communication fundamentals for everyday life, proposing them an introduction to French culture and civilization and more advanced knowledge in order to work in a French company during the final internship period.

ENSEA

Beyond Engineering

RF Engineering

Graduate/Master Program

ENSEA – Semester 9 ESC - French-Taught

Edition 2023

RF Engineering
ENSEA - ESC 3rd Year Academic Track

Level	**Second year of Master's Degree/Graduate/Semester 9**		
Period	Fall semester (September to January)		
Language of tuition	French		
ECTS	30		
Courses	Code	Course	ECTS
	ESC_1	**RF Communication Systems [Composed of:]**	**6**
	ESC_3961	Wireless Communication Systems	
	ESC_3940	Antennas	
	ESC_3910	Guided Waves	
	ESC_2	**Electronics for High-Speed Communication [Composed of:]**	**5**
	ESC_3950	High-Speed Electronics	
	ESC_3920	RF Semiconductor Devices	
	ESC_3	**RF device design [Composed of]**	4
	ESC_3931	Non-linear RF Design	
	ESC_3930	Linear RF Design	
	ESC_4	**Project [Composed of:]**	5
	ESC_3901	Circuit Project	
	ESC_5	**Acquisition Systems [Composed of:]**	**5**
	ESC_3900	System Project	
	ESC_3902	CAD and Measuring Tools	
	ESC_3970	Conferences	
	SH-3EME	**Humanities [Composed of:]**	**5**
	DSH_3000	Human Resources Management and International Management	
	DSH_3060	English	
	DSH_3061	FLE (French for foreigners) or Spanish or German	

RF Engineering
ENSEA - ESC 3rd Year Academic Track

ESC_1 RF Communication Systems (6 ECTS)

ESC_3961 Wireless Communication Systems (Lectures: 10h / Tutorial classes: 10h / Lab: 16h)
This course introduces the basics of formatting signals (modulation, coding), and the RF front-end structures. The knowledge provided by this course allows the student to analyze the functioning of a real system and to evaluate its performance. Experiments in labs give a first training with measuring and simulation methods.
- Constant-envelope or nonconstant-envelope modulations
- Amplitude, Phase, Frequency, OFDM, Spectrum
- Transmitter/receiver architecture
- RF segment constraints and defects
- System simulation: behavioral models, co-simulation

ESC_3940 Antennas (Lectures: 14h / Tutorial classes: 10h / Lab: 16h)
This course introduces the general concept of antennas, and studies key antennas from main technologies. This course has an interest in different methods of modeling antennas, especially the plane wave spectrum decomposition. Simulation models are presented. Practices in lab illustrate the theory by measuring specific antennas (quarter wave antennas …), in anechoic chamber or in free space, and it uses 2.5D electromagnetic simulations.
- Plane waves. Radiated power. Decomposition into plane wave spectrum
- General properties of antennas. Link budget, radiation pattern, gain, directivity, polarization....
- Study of some particular antennas: electric dipole, half-wave dipole, aperture antennas, slots and horns, patch antennas.
- Antenna array. Array factor and directivity.

ESC_3910 Guided Waves (Lectures: 10h / Tutorial classes: 10h / Lab: -h)
This course gives the basics of guided waves propagation, in order to prepare for the generalized concept of power waves. The electromagnetic functioning of waveguides is studied, millimeter-wave integrated circuits in particular. Then it explains dispersion and parasitic modes.
- Classical closed guides. Rectangular and circular guides.
- Miniature and integrated guides (triplate, microstip, coplanar guides).
- Electromagnetic simulation 2.5 D and 3D (TD)
Key words : Guided propagation, transmission lines, wave guide

ESC_2 Electronics for High-Speed Communication (5 ECTS)

ESC_3950 High-Speed Electronics (Lectures: 10h / Tutorial classes: 10h / Lab: 16h)

This course studies different modules of electronic interfaces (SFI-4) for optical communications at 10 Gb/s (SONET OC 192, SDH STM-64). The course also focuses on analog / digital interfaces for high speed electronics and measuring techniques. There is also practical work on CAD workstations, allowing students to design typical circuits using Cadence software.

ESC_3920 RF Semiconductor Devices (Lectures: 12h / Tutorial classes: 4h / Lab: 16h)

This course gives a qualitative presentation on how the components work, in order to suggest models and characterization techniques, together with equivalent circuits, linear or not, and of noise, for microwave circuits design.

It is illustrated by a Lab class on machines aiming at determining the elements of the linear equivalent diagram of a FET transistor from the Sij parameters as well as applied training of characterization with the network analyzer and measurement of the noise parameters.- Schottky and Varicap diodes,- MESFET, MOSFET, HEMT, HBT transistors.

Key words : Components, semiconductors, modeling, characterization.

ESC_3 RF device design (4 ECTS)

ESC_3931 Non-linear RF Design (Lectures: 10h / Tutorial classes: 8h / Lab: 8h)
This course presents the basics of designing nonlinear RF devices ("harmonic balance method"). In particular, methods for designing power amplifiers, oscillators and microwave mixers will be studied.- Power amplification: classes of operation, advanced architectures: distributed, Doherty and envelope tracking amplifier.- Oscillators: Design methods, dielectric resonator oscillators, tunable oscillators.- Mixers- Non-linear stability analysis
Keywords: High efficiency power amplifier, microwave oscillators, mixers and nonlinear stability analysis

ESC_3930 Linear RF Design (Lectures: 10h / Tutorial classes: 6h / Lab: 8h)
This course presents the general methods for analyzing circuits (S parameters, multipoles). It also presents the main methods to design passive circuits (filters, couplers) and active circuits (amplifiers, oscillators).
There are some exercises using Computer-Aided Design (CAD). The tutorials use CAD to consider parameters and phenomena too complicated to handle without CAD.
- General analysis methods. S-parameters, fluence graphs, passive and active quadrupoles, multipoles, linear stability criteria, noise parameters.
- RF amplifiers. Narrow band amplification (+TP), broadband amplification, reactive matching, noise factor.

ESC_4 RF Project (5 ECTS)

ESC_3901 Circuit Project (Lectures: -h / Tutorial classes: 6h / Lab: 36h)
It is about designing a simple circuit of a communication system such as antennas and amplifiers for radio frequency applications. The study is preceded by a bibliographic research related to the subject. The circuit is then designed, made, and measured. A project defense presents the results.

ESC_5 Acquisition Systems (5 ECTS)

ESC_3900 System Project (Lectures: -h / Tutorial classes: -h / Lab: 40h)
This project develops the skills necessary to implement a system or part of an acquisition or instrumentation system as well as a wireless communication system. Students will use acquisition and transmission cards (use of programming software such as LabVIEW).

ESC_3902 CAD and Measuring Tools (Lectures: 4h / Tutorial classes: -h / Lab: 24h)
This module presents the tools necessary for the use of specific measuring equipment and software for simulation commonly used in this field.
- Line theory. Reduced impedance, Smith chart, impedance matching
- Microwave measurements. Network analysis, correction of errors, noise factor measurement
- Presentation of CAD software, methods of analysis and optimization

ESC_3970 Conferences (Lectures: 10h / Tutorial classes: -h / Lab: -h)
The lectures are delivered by professionals from the field. The subjects covered may vary from one year to the next. The following topics are only a sample of possible themes.
MMIC technology and applications. Evolutions and recent developments in the field of video. Radar. Wireless applications: GSM, DECT, Wifi, Bluetooth, RFID, Satellite telecommunications…

SH_3EME Humanities (5 ECTS)

DSH_3000 Responsible and sustainable management of human resources in a complex environment

(Lectures: 16h / Tutorial classes: 6h / Lab: -h)

The course presents the evolution of organizations in a complex environment (team management, corporate culture in a multicultural context, professional project through the dynamics and management of evolutions). It emphasizes the strategic role of human resources management in a CSR context (Quality of Life at Work - OHS) in order to prepare engineering students (guided by the 26000 standard) for their role as project managers, project leaders or employees of a project team.

It introduces the notions of labor law that are essential for engineers (employment contracts, expatriation, work environment in the company) by integrating the social and societal concerns of the company.

The practical courses allow, through an edutainment approach (or in the form of a serious game):

- to implement an HRM that values responsibility and ethics (Remuneration, Training, Skills management, Health and Safety at work).
- Identify good practices to implement a CSR policy.

DSH_3060 English (Lectures: -h / Tutorial classes: 24h / Lab: -h)

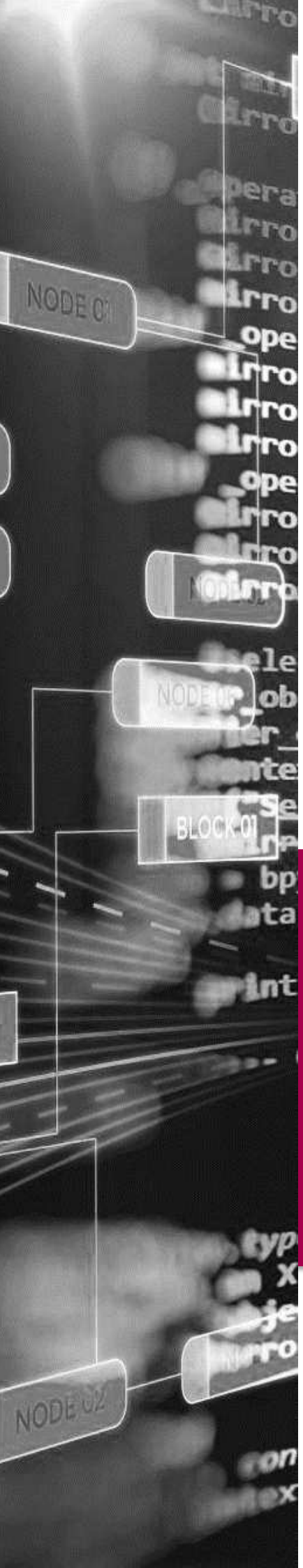
The objective of the third-year courses is to make the students able to work in English and have a good command of the language.

The goal is achieving a professional use and to reach, at least, a B2 level requested do obtain the degree.

Two third-year options are grouped together for English courses. Level groups can be formed. The students will be able to work on different aspects of life professional (communication in different settings, in the office, abroad, in seminars, through writing, orally, case studies...), by carrying out work groups and putting in practice the knowledge they have acquired throughout their training.

DSH_3061 FLE (French for foreigners) (Lectures: -h / Tutorial classes: 24h / Lab: -h)

The main goal of this class is training the foreign students through communication fundamentals for everyday life, proposing them an introduction to French culture and civilization and more advanced knowledge in order to work in a French company during the final internship period.



ENSEA

Beyond Engineering

Signal Processing and Artificial Intelligence

Graduate/Master Program

ENSEA – Semester 9 SIA - French-Taught

Edition 2023

Signal Processing and Artificial Intelligence
ENSEA - SIA 3rd Year Academic Track

Level	**Second year of Master's Degree/Graduate/Semester 9**		
Period	Fall semester (September to January)		
Language of tuition	French		
ECTS	30		
Courses	Code	Course	ECTS
	SIA_1	**Signal Processing [Composed of:]**	**6**
	SIA_3600	Advanced Signal Processing Methods	
	SIA_3602	Audio	
	SIA_2	**Digital and Image Processing [Composed of:]**	**6**
	SIA_3601	Advanced digital processing	
	SIA_3603	Images and Video Processing	
	SIA_3	**Artificial Intelligence [Composed of]**	3
	SIA_3611	Machine Learning	
	SIA_4	**Deep Learning and Hardware [Composed of:]**	**5**
	SIA_3607	Hardware for Signal Processing	
	SIA_3612	Deep learning for visual recognition	
	SIA_5	**Project [Composed of:]**	**5**
	SIA_3620	Project	
	SIA_3630	Conferences	
	SH-3EME	**Humanities [Composed of:]**	**5**
	DSH_3000	Responsible and sustainable management of human resources in a complex environment	
	DSH_3060	English	
	DSH_3061	FLE (French for foreigners) or Spanish or German	

Signal Processing and Artificial Intelligence
ENSEA - SIA 3rd Year Academic Track

SIA_1 Signal Processing (6 ECTS)

SIA_3600 Advanced Signal Processing Methods (Lectures: 20h / Tutorial classes: 12h / Lab: 16h)

Upon completion of this course, students will be familiar with signal processing tools that they can use to analyze and extract key parameters of a signal from observations. Offline and adaptive methods will be considered. They will implement them in the context of acoustic echo cancellation (audio conferencing) and data compression.

In particular, they will be able to:

Design an estimator without a priori (Maximum likelihood, EM algorithm) and analyze its performance (Cramer-Rao boundary),

Design a hypothesis test detector;

Apply it to non-destructive testing,

Design an estimation with a priori (Bayesian estimation, maximum a posteriori, linear regression),

In the linear case, design a filter minimizing the squared error (optimal Wiener filter, finite order Wiener filter) and

Implement an adaptive filter (LMS, NLMS, RLS algorithm); apply it to acoustic echo cancellation, or li-near prediction,

Implementation of a Kalman filter.

The practical work will concern source separation with applications such as cocktail party, acoustic echo cancellation, or texture estimation.

SIA_3602 Audio (Lectures: 12h / Tutorial classes: 8h / Lab: 16h)

The objective of this course is to present a range of the most recent technologies for the acquisition, automated processing and restitution of audio-frequency signals, in particular signals carrying musical information. The intended applications concern both consumer multimedia and professional production systems.

Acoustics: sound sources, propagation and radiation, speech, music and harmony, ...

Psychoacoustics and lossy compression such as MP3,

Audio processing chain: technological aspects and performances, lines, synchronization, pre-amplification, dithering, interconnection standards,

Architectures for digital audio signal processing: specialized processors, Codec, ALSA, I2S, SAI

Production and post-production: equalization, multi-band dynamic processors, noise reduction, spatialization, ...Digital music signal processing: specific Fourier transforms, source separation methods, P-SOLA, audio descriptors

Music Information Retrieval and Machine Learning: chord recognition, musical genre recognition, automatic synthesis and composition, ...

SIA_2 Digital and Image Processing (6 ECTS)

SIA_3601 Advanced digital processing (Lectures: 18h / Tutorial classes: 12h / Lab: 12h)

Multimedia signal compression standards (MP3, JPEG, MPEG) use signal decomposition and reconstruction techniques. The compression is carried out at the level of the decomposition signals, with in particular a quantization stage. These techniques must provide a perfect or near-perfect reconstruction in the absence of any compression. Quantization must take into account constraints such as the transmission channel rate or the desired distortion after reconstruction. This course presents the theoretical basis of these techniques, with an emphasis on perfect reconstruction systems. It also presents the principles of signal quantization modelling.

- Orthogonal transforms
- Multi-rate signal processing, bank of filters
- Orthogonal and bi-orthogonal wavelets
- Modelling the quantization of signals

SIA_3603 Images and Video Processing (Lectures: 12h / Tutorial classes: 8h / Lab: 16h)

This course presents the basics of image and video processing. It reviews the notions of digital signal processing specific to images and videos, as well as the perceptual aspects related to them. These notions are then applied to well known domains such as image or video compression, primitive extraction, image watermarking, etc. The goal of this course is to allow the student to acquire and master the tools present in an image or video processing chain.

- Direct Image Processing: contrast, smoothing, gradients, in-painting
- Processing through decomposition and related applications
- Image compression and related standards: PNG, GIF, JPEG, JPEG2000
- Video compression and related standards: MPEG-1, MPEG-2, MPEG2000, H264

SIA_3 Artificial Intelligence (3 ECTS)

SIA_3611 Machine Learning (Lectures: 16h / Tutorial classes: 14h / Lab: 16h)
This course introduces the fundamental concepts, theory and algorithmic ideas of machine learning. It provides the student with a foundation for applying machine learning techniques to real-world problems or for researching the development of new machine learning algorithms and methods. It also provides the foundation for several other data science courses, including deep learning. Specifically, the course focuses on the main techniques of supervised, unsupervised, and reinforcement-based machine learning. The following will be developed:

- Clustering: centroid-based, density-based, and distribution-based algorithms, agglomerative hierarchical clustering, expectation maximization for soft clustering.
- Linear regression: simple and multiple regression analyses, least squares method, maximum true likelihood estimation.
- Discriminative and generative classifiers: logistic regression, naive Bayes classifier, K-nearest neighbors, support vector machines, decision trees, random forests.
- Performance metrics, hyperparameter tuning and performance estimation protocols: ROC and AUC curves, cross-validation, nested cross-validation, bootstrapping, overfitting and model selection.
- Feature selection: forward-backward search, lasso, orthogonal matching search.
- Markov decision processes and dynamic programming: Bellman equations, policy iteration, value iteration.
- Monte Carlo methods: prediction and control variable.
- Temporal difference learning: Q-learning, deep Q-learning.

SIA_4 Deep Learning and Hardware (5 ECTS)

SIA_3607 Hardware for Signal Processing (Lectures: 4h / Tutorial classes: -h / Lab: 16h)

The implementation of algorithms processing large volumes of data is usually done using server-based solutions. However, the training phases of deep learning algorithms have a particularly high carbon footprint. Moreover, embedded algorithms, especially for IoT, rely on hardware implementations subject to severe power constraints. The objective of this course is therefore to make students aware of the hardware solutions currently available, their performance, their practical implementation, their respective roles in the prototyping stages and their ecological implications. Various targets can be considered, among which a particular target that students will be invited to choose according to their project topic (see SIA_3720). The practical sessions will allow students to become familiar with the design practices and treatments specific to the objective.

SIA_3612 Deep learning for visual recognition (Lectures: 12h / Tutorial classes: 6h / Lab: 16h)

Computer vision has become omnipresent in our society, with applications in image searching, mapping, medicine, drones, autonomous cars, and so on. Visual recognition tasks such as image classification, localization and detection are at the heart of these applications. Recent developments in deep neural network approaches (deep learning) have greatly advanced the performance of these visual recognition systems.

The following topics will be covered during this course:

Learning algorithms (backpropagation, dropout, batch normalization, transfer learning...)

Deep learning architectures for visual recognition tasks: Convolution Networks (ConvNet: AlexNet, ResNet, VGG,...), Recurrent Networks (RNN), Generative Models (PixelCNN, Generative Adversarial Networks - GAN,...),

Deep Compression,...

Case studies from research, image classification, image generation, object detection, image style change (DeepDream), semantic segmentation, etc. will illustrate these topics.

SIA_5 Project (5 ECTS)

SIA_3620 Project (Lectures: -h / Tutorial classes: -h / Lab: 68h)
This course offers students the opportunity to carry out a synthesis of the courses followed during the semester. They will have to achieve a bibliographical study, determine the objectives to be reached, plan the tasks to be carried out, achieve, identify the additional skills they will have to acquire and propose methodological solutions, to organize a working schedule and division within the frame of collective project, validate the main steps previously defined, regularly inform the supervisors of their project's progress, and finally present at the end of semester a functional production.
With regard to the hardware implementation of the algorithms in connection with SIA_3707, the training will focus on the choice of the target and of the particular
technical solutions planned in order to obtain, for example, the best compromise between efficiency and carbon footprint for server-based implementation or to optimize integration on an embedded target.

SIA_3630 Conferences (Lectures: 10h / Tutorial classes: -h / Lab: -h)
Several lectures will be given by specialists of the field, industrial engineers or researchers, to present flagship applications in the fields of artificial intelligence, specific data processing (audio, video, image…) or multipurpose techniques (remote sensing, robotics, etc.). The themes may vary from one year to the next according to the evolution of techniques and availability of lecturers.

SH_3EME Humanities (5 ECTS)

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