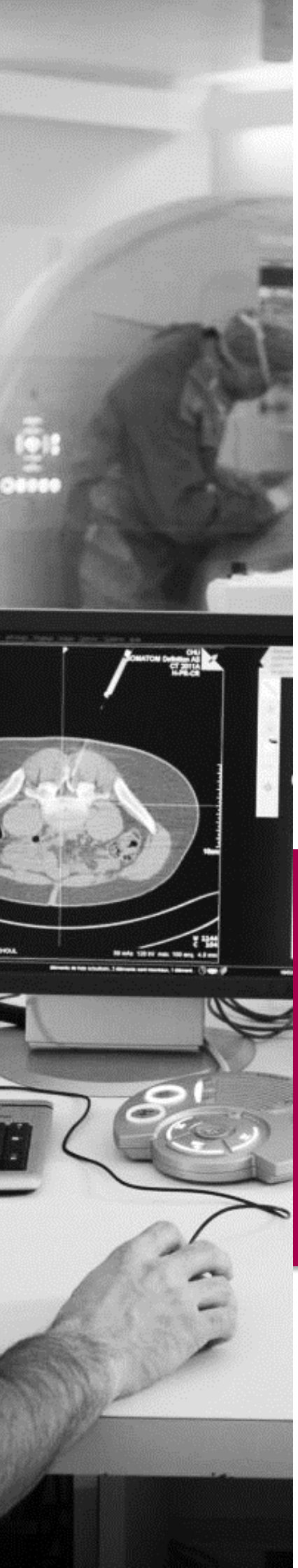

ENSEA

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.