ESIEE PARIS

MASTER OF ENGINEERING
"Applied Micro-and Nano-Technologies"

1st Year - Common Core

1st Semester	ECTS
0. Review of Electronic Fundamentals (optional) **Aim:** This course aims at providing a review of electronic basics to students that may come from non-electronic field such as physics and who may be interested in pursing studies in the electronic technologies field. This course will be specifically adapted to give these students all the fundamentals electronics pre-requisite for the Micro-and-Nano-Technologies option. **Content:** - Electrical circuits - Electronic basics and components - Operational Amplifier Circuits	3
1. Signal and Systems **Aim:** The objective of this course is to give an accessible introduction to signals and systems for electrical engineering, computer engineering, and computer science. **Content:** - Fundamentals of continuous-time/discrete-time signals: Fourier and Laplace transforms; Convolution and transfer function; Sampling and reconstruction - Essentials of feedback control: representation of dynamical systems; basic feedback loops and more abstract representations; structural properties; stability and sensitivity; control algorithms and methodologies (PID, state feedback, pole placement, observers) - Uncertainty and systems' limitations (measurement noise, actuator saturation, process dynamics)	3
2. Introduction to Material Sciences **Aim:** The course will offer a broad overview of materials science. Different examples of how the atomic and molecular structure of a material affects its larger-scale properties will be examined. "Designer" materials with exceptional electrical, mechanical and optical properties will be presented, along with techniques of manufacturing such materials by micro- and nano- patterning techniques. **Content:** - Review of semiconductors fundamentals and crystallography - Bulk and thin film material properties, soft matter and polymers - Nanotubes, nanowires and quantum dots - Nanopatterned optical materials and photonic crystal structures	3

3. Propagation and Technologies **Aim:** The course targets to train students in high frequencies technologies and techniques. Electromagnetism and propagation fundamentals will be initially reviewed. The course will then provide the audience with the tools to manipulate high frequency signals and will describe elements of technologies such as practical transmission lines, analog filters, resonators and passives components. Applications will be for the design of circuits and systems, including RF MEMS. **Content:** - Propagation basics review - High frequency techniques fundamentals - Transmission lines technologies - Analog RF filters, passives and resonators	3
4. C and C++ Programming **Aim:** This course targets to train students with computer languages. C and C++ programming will be developed mainly in on a project basis accompanied by introduction courses. Various application of C language to scientific and technical engineering tasks will be pursued. **Content:** - Introduction courses on languages and programming of hardwares - Short Project	3
5. Analog Circuits for Sensors and Receivers **Aim:** This course provides the audience with knowledge and techniques in building analog circuits for various sensing application as well as for communication receiver devices. It develops the necessary concepts and continues with circuit design examples, including practical experiments. **Content:** - Frequency stability and sensing for sensors and communications - Low noise and high sensitivity sensors and receivers - Power reduction and harvesting electronic circuits	3
6. Discrete Time Electronics and Applications **Aim:** This course is intended to develop techniques at the frontier of the digital and analog domains, such as design of analog circuits using switched capacitors, digital filters, etc. It will also give the opportunity to investigate analog applications of switched capacitor circuits such as power scavenging. **Content:** - Switched capacitors circuits - Digital filters - Power scavenging applications	3
7. Electron Devices, Components and Models **Aim:** The aim of this course is to deal with the elementary electron devices that are commonly used in all integrated circuits, and to develop un understanding of relevant physical effects and their modeling. The focus will be put on bipolar structures on one hand, such as PN diodes and bipolar transistors on Silicon, and on unipolar devices on the other hand with Schottky diodes and MOS transistors. Their electrical modeling will be a key to the design of integrated circuit. An introduction to compact circuit models topology will last be given. **Content:** - Introduction to electrical and physical modeling - PN diodes and bipolar transistor effects - Schottky diodes and MOS transistor effects	**3**

8. Data Acquisition and Converters **Aim:** This course will provide the attendees with fundamentals of signal conversion between the analog and digital domains. The subject will first be handled theoretically by studying the theory of acquisition chains and will be continued toward designing practical circuits and understanding the limits of standard digital to analog (D/A) and analog to digital (A/D) converters. **Content:** - Description of acquisition chains and theory, - A/D and D/A converters principles - Converters architectures	**3**
9. French Language	3
10. French Culture and Intercultural	3
11. Management - Marketing - Finance - IT law	2
2nd Semester	
1. Analog IC Design **Aim:** This course provides an extensive study of the use of transistors within digital and analog ICs. An understanding on the tailoring of the transistor in so-called full custom IC design methodology will be given. Bipolar and CMOS technologies will be compared together with BiCMOS. Improvement from high-speed differential stages toward low power, low noise or higher speed applications will be finally detailed. **Content:** - Transistor Level Circuit Design (current mirror, active load…) – review of most common circuits - Analog Full custom IC design (Bipolar, CMOS and BiCMOS) - High speed differential stages	3
2. Sensor Principles **Aim:** As Sensors are often the key components of many electronic systems, this course will provide the required knowledge on such special components to enable designing basic sensors of various types. The focus will be given to multi-physics micro-components including optoelectronic and MEMS sensors **Content:** - Basics of metrology, measurement chain and closed-loop operations - Optical, magnetic and thermal sensors - Electromechanical, magneto-mechanical, thermo-mechanical effects and transducers **Keynote advanced Lab Sessions** - Experimental sensor characterization	3

3. Optoelectronic and Photonic **Aim:** The aim of this course is to provide students with the knowledge of optical principles and material properties for optoelectronic applications and also to detail the various mechanisms involved in the design of optical passive and active components including optical MEMS. A final synthesis will be given to introduce the techniques for optical link design. **Content:** - Optoelectronic material properties - Passive optical components for guided and free-space propagation, Fibres and optical MEMS - Semiconductors and active optical components - Optical link design	3
4. Introduction to MEMS, Microfluidics and Nanoscience **Aim**: The course will offer an introduction to several emerging technologies from multiple perspectives. Going from fundamental to applied, we will gradually learn about the phenomena and technologies encountered at microscopic scales and harness to provide components and systems that perform complex tasks better, faster and cheaper. We will then move to different application areas which were recently revolutionized by the introduction of micro and nano technologies **Content:** - Introduction to MEMS , microfluidics, NEMS and nanodevices. - Microscale phenomena: the world seen from below - MEMS and applications (automobile, optics, microwave, defense) **Keynote advanced Lab sessions** - Introduction to microfabrication in cleanroom	3
5. Introduction to Communication Systems **Aim:** This course browses main communication applications with the desire to present the market, the network architecture with an insight in electronic technologies involved. At the end, design requirements will be derived from the system level to the individual device. **Content:** - Wireless technologies and standards, RFID - Wired and Optical networks - Satellite communications	3
6.1 Simulation of Heterogeneous Domains (elective) **Aim:** The objective of this course is to study the principles of modeling and simulation of complex heterogeneous devices and systems. Numerical methods including FEM will be studied in detail. On the other hand, an introduction will also be given to global behavioral simulation methods of components and systems. **Content:** - FEM Modelling: Theory and application - Analog behavioural modelling VHDL-AMS and System-C AMS - Co-simulation techniques	3
6.2 Communication circuits architecture (elective) **Aim:** This course aims to provide students with the description of standard communication systems architectures. It will then describe how those topologies lead to individual requirements for the system itself as well as for individual sub-systems and devices. Several critical sub-systems will then be analyzed in detailed such as non-linear continuous wave amplifier and filters. From this approach, complete linear and non-linear budget of the communication link will be established. **Content:** - Standard transceiver topology and design - Analysis of system performances - Analysis of some sub-systems (NL CW amplifiers, filters…)	3
7. French language	2

8. Management **Content:** - Strategy - Entrepreneurship - Change management - Human ressources	2
9. Project	5
Total	**60**

2nd YEAR

"Wireless Communication Option"

1st Semester	ECTS
1. Advanced Electron Devices **Aim:** The purpose of this course is to describe the physics and the electrical modeling of the most advanced technologies used nowadays in all digital, analog and optoelectronic applications. The course will also provide description of advanced compact-circuit models that are mandatory for any circuit design. The proper choice of this model with respect to the designed circuit is a critical point. Finally overview of available industrial technology will be provided with insight on how to select the technology of choice regarding the targeted application requirements. **Content:** - Advanced CMOS technologies - Heterojunction materials and devices (HBT, HFET, Optoelectronic) - Advanced Compact-circuit-models - Overview of industrial technologies (RF IC and MMIC)	3,5
2. RF and Microwave Circuits Fundamentals **Aim**: This course is the following of the "Communication circuits architecture" course and will focus on the design of every typical Radio-Frequency (RF) integrated circuits, from amplifiers to filters and A/D or D/A converters. Finally selection criteria for IC technologies will given to optimize the circuits performances. **Content:** - RF and microwave circuits fundamentals - Design of low-noise and high-power amplifiers - Design of mixers and oscillators - High speed D/A and A/D converters - Filter technologies - Selection criteria for IC technologies versus performances	3,5

3. Digital Communication Standards and RF Front-Ends **Aim:** The aim of this course is to develop on the fundamentals of digital communication standards with a special focus on the advanced standards in next generation communication systems. Design of complete RF front-ends will be browsed from both theory and practical point of view through an important training session on OFDM front-ends design. **Content:** - Digital communication standards - Multi-carrier modulation format (OFDM…) - Transceivers for new wireless standards **Keynote advanced Lab sessions** - Training on OFDM front-ends design	3,5
4. From RF to Millimetre Circuits Design **Aim:** This course is an intensive and practical training on complete RF and millimeter wave monolithic ICs design. Clear hand-ons will be given to attendees with the highly enriching and exciting occasion to work on the most advanced CMOS or BiCMOS technologies internationally available. Students will design their own circuits that will be processed in real multi-project-wafer run. Testing will be provided through the “test and measurement” course. **Content:** - Si-based and III-V technologies - Practical design training on RF IC / MMIC **Keynote advanced Lab sessions** - Training on Europractice Technologies	3,5
5. Electromagnetic Modeling **Aim**: This course introduces electromagnetic modeling applied to the integration of a system into its package. This aspect is a key challenge that it is crucial to solve in the industry and to which development of numerical tools turned on. Attendees will also investigate system-on-chip and system-in-package integration techniques. **Content:** - Numerical tools - Passives electromagnetic modeling - EMC and Packaging - System on chip (SoC) and in Package (SiP) integration	3,5
6. Antennas and Propagation **Aim:** The aim of this course is to train students toward the techniques of antenna design. Channel modeling will allows to derive most of the constraint to be used in the further integration of single and multi-antenna systems. **Content:** - Channel modeling - Integrated antennas - Multi-antenna systems	3,5
7. Test and Measurement **Aim:** This courses will be focused on the measurement techniques to be involved in the characterization of components, devices, circuits and systems in the various field of the high-frequency domains: from the RF to the millimeter waves and up to the digital communications system level. Automation of measurement will also be dealt to optimize the performance of measurements setup. **Content:** - Test of Analog, RF and Microwave communications circuits - Microwave measurement techniques. On-chip probing. - Automation techniques and data acquisition **Keynote advanced Lab sessions** - Courses completely turned on Lab sessions practice - Access to a complete microwave measurement platform (from DC to 67GHz)	3,5

8. French Language	2
9. International Management	2
10. Entrepreneurship and Innovation	2
2nd Semester	
Final Project and Thesis	30
Total ECTS	60,5

2nd YEAR - "Micro- and Nano- Systems" Option

1st Semester	ECTS
1. Microfabrication Technologies for ICs and MEMS **Aim:** This course is intended to give the knowledge of fundamental semiconductor processing, including microfabrication of both integrated electronic circuits as well as MEMS devices. The most conventional technology steps will be detailed. Typical process flows will be discussed as well. This course will be concluded by an experimental lab session in which MOS circuits will be fabricated and tested. **Content:** - Fundamentals of semiconductor materials and processing. - Introduction to MEMS fabrication technologies. - Polymer materials and related technologies. - Typical process flows of IC and MEMS foundry services - Keynote advanced Lab session - Fabrication and test of MOS circuit in clean-room	3,5
2. Nano & Bio-chemical Technologies and Devices **Aim:** The objective of this course is two-fold: Part 1 - Give a general introduction to the techniques of nanofabrication, including top-down approaches and Bottom-up self-assembly techniques. Part 2 - Introduce principles and technologies for chemical and biological sensors and interfaces as well as problems of their implementation on a micro-chip. **Content:** - Top-down nanotechnology (e-beam and ion-beam writing, soft lithography and nanoimprint, Atomic probe techniques, Nanotubes and Nanowires) - Emerging Bottom up techniques: block copolymer nanotechnology and DNA self-assembly - Background on surface science and chemistry. Scaling laws in (bio)chemical process. Fundamentals of molecular biology, biochemistry, and cell biology - Electrochemical sensors, functionalized-surface chemical and biochemical sensors - Optical spectroscopy techniques, Chromatography and Mass spectrometry - The Lab-On-Chip implementation : Bio-chips, Bio-Sensors and Bio-MEMS Background on semiconductor physics	3,5
3. Characterization at the Micro- and Nanoscale **Aim:** The aim of this course is to give a comprehensive description of characterization tools used in material science as well as those used for multi-physics behavioral characterization. Focus is put on selected experimental setups, including the most widely used in nanotechnology and MEMS **Content:** - Near Field Microscopy : AFM, STM, SNOM, Nanoindentation - Scanning Electron Microscopy,Transmission Electron Microscopy, EDS, EDX - X-Ray Diffraction - Optical techniques for profilometry, vibrometry and spectroscopy, and ellipsometry **Keynote advanced Lab Session :** Practice on Characterization Tools	3,5
4. MEMS Design **Aim:** This course is dedicated to the design and simulation methods and tools for multi-physics components including MEMS. Important part will be dedicated to using major CAD software packages and to device implementation according to a specific design-kit of a MEMS foundry **Content:** - Design Methodologies and flow - Practice of ANSYS and COVENTOR - Detail of the Design-kits used for MUMPS foundry - Structural simulation and Coupled simulation case studies **Keynote advanced Lab Session :** Design of MEMS inertial sensor for fabrication in MUMPS foundry	3,5

5. Microfluidics **Aim:** This course covers the emerging field of Microfluidics from both a fundamental and an applied perspective. We will look at miniaturization effects in fluidic devices and will study the concepts of digital microfluidics, and its various applications to the biotech and pharmaceutical industries. Different manufacturing techniques will be described in detail and hands-on experience will be integral to the class. **Content:** - Physics at the microscale (small Reynolds number flows, capillarity effects…) - Single-phase fluidics, multi-phase and digital microfluidics, Fluid manipulations. - Manufacturing techniques - Specific physical sensors and industrial applications **Keynote advanced Lab Session :** Microfluidic device fabrication	3,5
6. Measurement System Design **Aim**: This course is a self-contained class addressing the question of how to design a measurement system for specific or industrial applications. Starting with problem-framing, we'll learn to define the correct measurement needs, and to make appropriate technology choices subject to constraints such as performance, cost, environment, size and power consumption. We'll continue with an overview of data acquisition and synchronisation, as well as sensor communication techniques. Several realistic examples will be reviewed **Content:** - Problem framing, Measurement needs, Technology choices - Acquisition and communication - Embedded systems and sensor networks - Data analysis and interpretation. Data presentation techniques	3,5
7. MEMS for Communications & Eco-technologies **Aim:** The objective of this course is two-fold: Part 1 – Develop the concepts and applications of MEMS to the field of communications, mainly through RF-MEMS and optical MEMS. Part 2 – Develop eco-technologies with special focus on energy. Different approaches for energizing miniature components are presented along with the corresponding technologies **Content:** - RF-MEMS devices, principles and applications. Integration in wireless communication systems - Optical MEMS: physical principles and applications (optical communication networks, display systems and sensors). Micro-optical devices with non-planar topographies. - Renewable energies. Low-power consumption strategies and corresponding technologies. Energy scavenging and harvesting. Review of solar, electromagnetic, thermal and vibrational, energy scavenging - Microbatteries, Microfuel-cells : material properties and architectures - Nanostructured surfaces and nanomaterials : Properties and applications	3,5
8. French language	2
9. International Management	2
10. Entrepreneurship and Innovation	2
2nd Semester	
Final Project and Thesis	30
Total ECTS	**60,5**