

SCIENCES, INGÉNIERIE ET TECHNOLOGIES

Ingénieur ENSEEIHT Electronique et Génie Electrique



Target level
BAC +5

Subprograms

- Ingénieur ENSEEIHT Electronique et Génie Electrique
- Ingénieur ENSEEIHT Electronique et Génie Electrique (Apprentis)

Presentation

Program

Ingénieur ENSEEIHT Electronique et Génie Electrique

Ingénieur ENSEEIHT Electronique et Génie électrique (En-Ge) 1ère année

Semestre 5 3EA-FISE

	Nature	CM	TD	TP	Crédits
Integration and probabilities	UE				5 credits
Integration	UE				
Complex Variable	UE				
Probabilities	UE				
Introduction to Algorithmic, Programming and Computer Architecture	UE				5 credits
Algorithms and Imperative Programming	UE				
Architecture and Assembler-programming	UE				
Digital Systems Design	UE				5 credits
Theoretical Approach of combinational and sequential logic	UE				
Digital Functions and Technologies	UE				
Project : Design of sequential and combinatoria Digital units	UE				
Fundamental Circuit Theory	UE				5 credits
Electric Circuits Analysis Methods	UE				
Instrumentation and Power Circuits	UE				
Circuits labs	UE				
Physics for Electrical Engineering	UE				5 credits
Electromagnetism	UE				
Material Physics	UE				
Propagation in Transmission Lines	UE				
Soft and Human Skills	UE				5 credits
Anglais	Matière				
Second language	Choix				
Spanish	Matière				
Portuguese	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
French as a Foreign Language	Matière				
LSF - S5	Matière				

Sports
Leadership and management

Matière
Matière

Semestre 6-3EA-FISE

	Nature	CM	TD	TP	Crédits
Numerical Analysis and Statistics	UE				5 credits
Differential Calculation and Optimisation	UE				
Solving PDEs using finite differences	LV2				
Statistics	facultative				
Signal and Control	UE				5 credits
Signal Processing	UE				
Digital Signal Processing	UE				
Continuous Linear Systems Control	UE				
Electric circuits and systems	UE				5 credits
Modeling by physical analogies & analysis	UE				
Op-amps and Compensation	UE				
Course (1 choice out of 2)	UE				
Advanced Amplifier Systems	UE				
Modeling of magnetic circuits	EC				
Components and Architecture	UE				5 credits
Semiconductors Physics and PN Junctions	UE				
Signal and Power Transistors	UE				
Course (1 choice out of 2)	UE				
Transistors Amplifier Circuits	UE				
Introduction to Static Conversion	UE				
Teaching unit (1 choice out of 3)	UE				5 credits
CONNECTED OBJECTS	UE				5 credits
Connected Objects	UE				
Connected Objects	UE				
ELECTRICAL PLANE	UE				5 credits
Airplane Electrical Networks	UE				
Basic Structures for C/A and A/C Conversion	UE				
Electromecanic conversion	UE				
Airplane Electrical Networks	UE				
Basic Structures for C/A and A/C Conversion	UE				
Electromecanic conversion	UE				
INTRODUCTION TO TELECOMMUNICATIONS	UE				5 credits
Introduction to Digital Communications	Matière				
Introduction to networks	Matière				
SOFT AND HUMAN SKILLS 2	UE				5 credits
Élément à choix UE SHS S6 FISE	Élément constitutif				

English	Matière
Sports	Matière
Leadership Part 1 - S6	Matière
Leadership Part 2 - S6	Matière
Entrepreneurship Part 1 - S6	Matière
Entrepreneurship Part 2 - S6	Matière
Citizenship Part 1 - S6	Matière
Citizenship Part 2 - S6	Matière
Agile methods	Matière
Managership P1-S6	Matière
Managership P2-S6	Matière
Spanish	Matière
Portuguese	Matière
Chinese	Matière
Italian	Matière
Japanese	Matière
Russian	Matière
German	Matière
French as a Foreign Language	Matière
FSL - S6	Matière

Ingénieur ENSEEIHT Electronique et Génie électrique (En-Ge) 2ème année

Semestre 7 - Parcours à choix (manuel)

	Nature	CM	TD	TP	Crédits
Semestre 7 - Electronics (EN)	Choix				30 credits
RADIOFREQUENCY ANALOG ELECTRONICS	UE				5 credits
RF Active Circuits	UE				
PLL and Oscillators	UE				
Analog Filtering	UE				
TP Advanced Design System (ADS)	UE				
LOW FREQUENCY ANALOG ELECTRONICS	UE				5 credits
Amplification classes	UE				
Analog Project	UE				
DIGITAL ELECTRONICS	UE				5 credits
VHDL	UE				
Front-End instrumentation	UE				
ELECTROMAGNETIC PROPAGATION	UE				5 credits
Guided propagation	UE				
Ideal Passive Circuits	UE				
Transmission Lines	UE				
INFORMATION PROCESSING	UE				5 credits
Random Signals	UE				
Object-Oriented Programming (POO)	UE				

Microprocessor	UE	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.1 : Presentations	Matière	
2nd language	Bloc	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
French as a Foreign Language	Matière	
LSF - S7	Matière	
Sports	Matière	
Leadership & Management	Matière	
Semestre 7 - Electronics, Electrical Energy and Simulations (EEES)	Choix	30 credits
ELECTROMAGNETIC PROPAGATION	UE	5 credits
Guided propagation	UE	
Ideal Passive Circuits	UE	
Transmission Lines	UE	
COMPUTER SCIENCE AND ANALOG FILTERING	UE	5 credits
Analog Filtering	UE	
Object-Oriented Programming (POO)	UE	
Reliability of numerical calculations	Matière	
SCIENTIFIC COMPUTING FOR ELECTRICAL ENGINEERING	UE	5 credits
Random Signals	UE	
Numerical analysis	Matière	
Numerical Methods for PDE	Matière	
POWER ELECTRONIC COMPONENTS AND MECATRONIC	UE	5 credits
Electro-megneto-thermal modeling and simulation of power electronic components	Matière	
Principle and structure of machines	Module	
ELECTRICAL MACHINE MODELING AND NUMERICAL SIMULATION	UE	5 credits
Electromagnetic modeling of machines	UE	
Numerical experiences	Matière	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.1 : Presentations	Matière	
2nd language	Bloc	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
French as a Foreign Language	Matière	

LSF - S7	Matière	
Sports	Matière	
Leadership & Management	Matière	
Semestre 7 - Energy (NRJ)	Choix	30 credits
COMPUTER SYSTEMS ARCHITECTURE AND DEVELOPMENT	UE	5 credits
Object-oriented design and programming	UE	
Principles of Operating Systems	UE	
Computer Architecture	UE	
STATIC CONVERTER SYNTHESIS AND DESIGN	UE	5 credits
Energy approaches to the design of static converters	UE	
Static Converter Design Project	UE	
ELECTRICAL MACHINES	UE	5 credits
Electromagnetic modeling of machines	UE	
Principle and structure of machines	Module	
ELECTRICAL NETWORKS	UE	5 credits
Energy of today and tomorrow	UE	
Electrical energy technology	UE	
Electrical energy transmission network	UE	
Modulation and filtering of voltage inverters	UE	
LINEAR SYSTEMS CONTROL	UE	5 credits
Identification	UE	
Sampled systems	UE	
Synthesis of correctors and control architectures	UE	
Automatic Tutorials	UE	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.1 : Presentations	Matière	
2nd language	Bloc	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
French as a Foreign Language	Matière	
LSF - S7	Matière	
Sports	Matière	
Leadership & Management	Matière	

Semestre 8 - Parcours à choix (manuel)

	Nature	CM	TD	TP	Crédits
Semestre 8 - Systems Integration (INSYS)	Choix				30 credits
FROM SILICON TO INTEGRATED CIRCUIT	UE				5 credits
From Silicon to Integrated Circuits	UE				

MICROWAVES	UE	5 credits
HFSS	UE	
Antennas Project	UE	
Microwave Project	UE	
Microwave Tutorials	Matière	
DIGITAL SYSTEMS ARCHITECTURE	UE	5 credits
Synchronous design of digital systems	Matière	
FPGA technology	UE	
Verification	EC	
CIRCUITS AND OPTOELECTRONICS	UE	5 credits
Analog integrated circuits	UE	
Optoelectronics	UE	
Optoelectronics Tutorials	Matière	
NANOSATELLITE SYSTEMS	UE	5 credits
Cubesat platform: an introduction	Matière	
Payload Sizing	Matière	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.2 : Debates	Matière	
Second language	Choix	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
french (as a foreign language)	Matière	
LSF - S8	Matière	
Sports	Matière	
Careers and Management - Sem.8	Choix	
Leadership	Matière	
Entrepreneurship	Matière	
Citizenship	Matière	
Managership-S8	Matière	
Semestre 8 -Communication Systems (SYSCOM)	Choix	30 credits
APPLIED MATHEMATICS	UE	5 credits
Advanced linear algebra	UE	
Hilbertian analysis	UE	
Optimisation under constraints	Matière	
PHYSICAL PHENOMENA AND MODELING	UE	5 credits
Electromagnetic radiation and antennas	Matière	
Physical analysis of guiding structures	UE	
Project: Modelling of structures in EM	Matière	
MICROWAVE DEVICES	UE	5 credits
Planar antennas and radiating apertures	UE	
Microwave Project	UE	

Microwave Tutorials	Matière	
SCIENTIFIC COMPUTING AND OPTOELECTRONICS	UE	5 credits
Finite elements for electromagnetism	Matière	
Programming for scientific computing	Matière	
Optoelectronics	UE	
Optoelectronics Tutorials	Matière	
NANOSATELLITE SYSTEMS	UE	5 credits
Cubesat platform: an introduction	Matière	
Payload Sizing	Matière	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.2 : Debates	Matière	
Second language	Choix	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
french (as a foreign language)	Matière	
LSF - S8	Matière	
Sports	Matière	
Careers and Management - Sem.8	Choix	
Leadership	Matière	
Entrepreneurship	Matière	
Citizenship	Matière	
Managership-S8	Matière	
Semestre 8 - Numerical Physics (PN)	Choix	30 credits
MECATRONICS	UE	5 credits
Materials	UE	
Smart Electroactive Materials	UE	
Modeling of electromagnetic systems using analytical calculations	UE	
Thermal and Fluid Mechanics	UE	
NUMERICAL PROJECTS	UE	5 credits
Numerical Project	Matière	
SCIENTIFIC COMPUTING	UE	5 credits
Numerical simulation in optics	UE	
Numerical analysis 2	Matière	
Programming for scientific computing	Matière	
Optimal design of a rocket nozzle actuator	UE	
Finite elements for electromagnetism	Matière	
PHYSICAL PHENOMENA AND MODELING	UE	5 credits
Electromagnetic radiation and antennas	Matière	
Physical analysis of guiding structures	UE	
Project: Modelling of structures in EM	Matière	
APPLIED MATHEMATICS	UE	5 credits

Advanced linear algebra	UE	
Hilbertian analysis	UE	
Optimisation under constraints	Matière	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.2 : Debates	Matière	
Second language	Choix	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
french (as a foreign language)	Matière	
LSF - S8	Matière	
Sports	Matière	
Careers and Management - Sem.8	Choix	
Leadership	Matière	
Entrepreneurship	Matière	
Citizenship	Matière	
Managership-S8	Matière	
Semestre 8 - Real-time automated systems (SATR)	Choix	30 credits
CONTROLLED, NON LINEAR SYSTEMS	UE	5 credits
State space	UE	
Introduction to Non-linear control	UE	
Non-linear control	UE	
Automatic Tutorials	UE	
DIGITAL CONTROL	UE	5 credits
Digital control	UE	
Digital Control Project	UE	
Industrial automation	UE	
Automatic Control Systems Tutorials	UE	
ELECTRICAL SYSTEM ARCHITECTURES AND CONTROLS	UE	5 credits
Electric vehicle motor sizing / CVS-Machines design elements	LV2	
	facultative	
Converter control	UE	
Machine control	UE	
ZOE powertrain project	UE	
DISCRETE AND SAMPLED EVENT SYSTEMS	UE	5 credits
Polynomial control	UE	
Graphs and Scheduling	UE	
Identification (recursive methods)	UE	
Automatic Tutorials	UE	
Petri network	UE	
NETWORK AND REAL-TIME SYSTEMS ENGINEERING	UE	5 credits
Distributed Computer Systems	UE	

Industrial networks	UE	
Real-time systems	UE	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.2 : Debates	Matière	
Second language	Choix	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
french (as a foreign language)	Matière	
LSF - S8	Matière	
Sports	Matière	
Careers and Management - Sem.8	Choix	
Leadership	Matière	
Entrepreneurship	Matière	
Citizenship	Matière	
Managership-S8	Matière	
Semestre 8 - Mechatronic System (SM)	Choix	30 credits
CONTROLLED, NON LINEAR SYSTEMS	UE	5 credits
State space	UE	
Introduction to Non-linear control	UE	
Non-linear control	UE	
Automatic Tutorials	UE	
DIGITAL CONTROL	UE	5 credits
Digital control	UE	
Digital Control Project	UE	
Industrial automation	UE	
Automatic Control Systems Tutorials	UE	
ELECTRICAL SYSTEM ARCHITECTURES AND CONTROLS	UE	5 credits
Electric vehicle motor sizing / CVS-Machines design elements	LV2	
	facultative	
Converter control	UE	
Machine control	UE	
ZOE powertrain project	UE	
ACTUATION MATERIALS	UE	5 credits
Materials	UE	
Smart Electroactive Materials	UE	
Finite element methods	UE	
Lagrangian approach to electromechanical systems	Matière	
ANALYTICAL AND PHYSICAL TOOLS FOR MECHATRONICS	UE	5 credits
System optimization and optimal design	UE	
Optimal design of a rocket nozzle actuator	UE	
Modeling of electromagnetic systems using analytical calculations	UE	

Thermal and Fluid Mechanics	UE	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.2 : Debates	Matière	
Second language	Choix	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
french (as a foreign language)	Matière	
LSF - S8	Matière	
Sports	Matière	
Careers and Management - Sem.8	Choix	
Leadership	Matière	
Entrepreneurship	Matière	
Citizenship	Matière	
Managership-S8	Matière	
Semestre 8 - Electrical systems of the future (SEF)	Choix	30 credits
CONTROLLED, NON LINEAR SYSTEMS	UE	5 credits
State space	UE	
Introduction to Non-linear control	UE	
Non-linear control	UE	
Automatic Tutorials	UE	
DIGITAL CONTROL	UE	5 credits
Digital control	UE	
Digital Control Project	UE	
Industrial automation	UE	
Automatic Control Systems Tutorials	UE	
ELECTRICAL SYSTEM ARCHITECTURES AND CONTROLS	UE	5 credits
Electric vehicle motor sizing / CVS-Machines design elements	LV2	
	facultative	
Converter control	UE	
Machine control	UE	
ZOE powertrain project	UE	
IMPLEMENTATION OF SWITCHING CELLS	UE	5 credits
Switching Mechanisms in Static Converters	UE	
Thermal	UE	
Static Converter close control project	UE	
RENEWABLE ENERGIES AND FACTS	UE	5 credits
Introduction to FACTS	UE	
Renewable energy: wind and solar power	UE	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.2 : Debates	Matière	
Second language	Choix	

Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
french (as a foreign language)	Matière	
LSF - S8	Matière	
Sports	Matière	
Careers and Management - Sem.8	Choix	
Leadership	Matière	
Entrepreneurship	Matière	
Citizenship	Matière	
Managership-S8	Matière	
Semestre 8 - Artificial intelligence for information processing (IATI)	Choix	30 credits
APPLIED MATHEMATICS	UE	5 credits
Advanced linear algebra	UE	
Hilbertian analysis	UE	
Optimisation under constraints	Matière	
DIGITAL SYSTEM ARCHITECTURE	UE	5 credits
Synchronous design of digital systems	Matière	
FPGA technology	UE	
DSP	UE	
IMAGE AND SIGNAL PROCESSING MODELING	UE	5 credits
Image processing	UE	
Image Project	Matière	
Modeling	UE	
Elective Course: Advanced Study in IATI	Bloc	10 credits
Advanced Study SIA	Choix	
SIGNAL ADVANCED METHODS	UE	5 credits
Signal representation and analysis	Matière	
Optimal filtering	Matière	
Multivariate analysis	Matière	
Inverse problems	Matière	
AI FUNDAMENTALS	UE	5 credits
Information Theory	Matière	
Introduction to Deep Learning	Matière	
Statistics - advanced methods	Matière	
Computational statistics	Matière	
Advanced Study TSE	Choix	
SIGNAL ADVANCED METHODS	UE	5 credits
Signal representation and analysis	Matière	
Optimal filtering	Matière	
Multivariate analysis	Matière	
AI INTRODUCTION	UE	5 credits

Introduction to Deep Learning	Matière	
General AI integration: first hardware integration	Matière	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.2 : Debates	Matière	
Second language	Choix	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
french (as a foreign language)	Matière	
LSF - S8	Matière	
Sports	Matière	
Careers and Management - Sem.8	Choix	
Leadership	Matière	
Entrepreneurship	Matière	
Citizenship	Matière	
Managership-S8	Matière	

Semestre 7 3EA FISE Parcours - EEES

Semestre 7 3EA FISE Parcours Energie

Ingénieur ENSEEIHT Electronique et Génie électrique (En-Ge) 3ème année

Semestre 9 - Parcours à choix (manuel)

	Nature	CM	TD	TP	Crédits
Semestre 9 - Systems Integration (INSYS)	Choix				30 credits
ANALOG ELECTRONIC SYSTEMS IN RADIOFREQUENCIES	UE				5 credits
Optoelectronic Components and Circuits	Matière				
Filter Synthesis	Matière				
Integrated photonics	Matière				
Internet of Things	Matière				
DIGITAL SYSTEMS	UE				5 credits
Synthesis strategy	Matière				
EMC for integrated circuits	Matière				
System on Chip	Matière				
ANALOG AND DIGITAL SYSTEMS	UE				5 credits
ADC and DAC	Matière				
Space Embedded Systems Conferences	Matière				
Integration of instrumentation chains	Matière				
Reliability of embedded systems	Matière				

1st ELECTIVE TEACHING UNIT	UE	5 credits
ADVANCED DIGITAL ELECTRONICS	UE	5 credits
FPGA system design for signal processing	Matière	
Circuit testing and fault simulation	Matière	
ADVANCED ANALOG ELECTRONICS	UE	5 credits
Introduction to Cadence Layout XL / Spectrum	Matière	
Analog ASIC project	Matière	
2nd ELECTIVE TEACHING UNIT	UE	5 credits
POWER MANAGEMENT	UE	5 credits
Microprocessor Power Supply	Matière	
MOSFET Driver Circuits	Matière	
EMC for SMPS	Matière	
FEM Modeling of Integrated passive filters	Matière	
ADVANCED RADIOFREQUENCY ELECTRONICS	UE	5 credits
RF equipment	Matière	
MMIC	Matière	
MEMS	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1-Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Communication Systems (SYSCOM)	Choix	30 credits
APPLIED PHYSICS AND NUMERICAL METHODS	UE	5 credits
Electromagnetism and multiscale devices	Matière	
Multiphysics Models	Matière	
Electromagnetism and nanoelectronics	Matière	
Synthesis of High Frequency Equivalent Electrical Circuits	Matière	
HIGH FREQUENCY EMBEDDED SYSTEMS	UE	5 credits
Microwave and Optical Sensors	Matière	
HF optoelectronic components and circuits	Matière	
Internet of Things	Matière	
Passive high frequency devices in waveguide technology	Matière	
MICROWAVE CIRCUITS AND ELECTROMAGNETIC COMPATIBILITY	UE	5 credits
Antenna networks	Matière	
Space antennas	Matière	
Aeronautical EMC 1	Matière	
Space Embedded Systems Conferences	Matière	
Microwave power amplifiers	Matière	
Aeronautical EMC 2	Matière	

PROPAGATION PHENOMENA AND RADAR	UE	5 credits
Actual propagation of electromagnetic waves	Matière	
Electromagnetic diffraction analysis / Radar equipment	Matière	
Radar project	Matière	
ELECTIVE TEACHING UNIT	Choix	5 credits
ADVANCED RADIOFREQUENCY ELECTRONICS	UE	5 credits
RF equipment	Matière	
MMIC	Matière	
MEMS	Matière	
MODELING	UE	5 credits
Variational methods for solving partial differential equations of physics	Matière	
Integral methods	Matière	
Plasma physics and applications	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1-Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Computational Physics (PN)	Choix	30 credits
ENVIRONMENT FOR INTENSIVE COMPUTING	UE	5 credits
BES langages avancés (C++, Phyton)	Matière	
Environnement Logiciel du Calcul Scientifique	Matière	
Techniques de génération maillage, pré/post processing	Matière	
NUMERICAL METHODS FOR DIFFRACTION PROBLEMS	UE	5 credits
Integral methods	Matière	
Electromagnetic diffraction analysis / Radar equipment	Matière	
PHYSICS FOR MECHATRONICS	UE	5 credits
Plasma physics and applications	Matière	
Advanced phenomena in electromechanical conversion	Matière	
Modeling of coupled phenomena	Matière	
Introduction to Magnetohydrodynamics	Matière	
EMC AND APPLIED MATHEMATICS	UE	5 credits
Aeronautic EMC 1	Matière	
Electromagnetic compatibility	Matière	
High Performance Computing	Matière	
Variational methods for solving partial differential equations of physics	Matière	
Multiphysics Models	Matière	
NUMERICAL METHODS AND OPTIMISATION	UE	5 credits
Topological Optimisation	Matière	
Finite element numerical modelling	Matière	

Optimal control	Matière	
Finished volumes	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional Communication and English-Semestre 9	Bloc	
Scientific English	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX Careers and Management 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and Social Responsibility	Matière	
Semestre 9 - Control Architecture Computer Science and Embedded Systems (ACISE)	Choix	30 credits
SYSTEMS CONTROL, FILTERING AND DIAGNOSTIC	UE	5 credits
Filtering estimation	Matière	
System Monitoring and Diagnostics	Matière	
Multidimensional Systems	Matière	
SYSTEMS OPTIMISATION AND THEIR CONTROL	UE	5 credits
Robust control	Matière	
Optimal Control	Matière	
Combinatorial optimization	Matière	
Opti TER	Matière	
Linear programming and unimodularity	Matière	
Continuous optimization	Matière	
MODELING, ANALYSIS, SIMULATION OF DISCRETE SYSTEMS	UE	5 credits
Modeling and analysis of discrete systems	Matière	
Simulation of discrete event systems	Matière	
Planning and Scheduling	Matière	
Hybrid Dynamic Systems	Matière	
Flexible Workshop TER	Matière	
ADVANCED CONTROLLED SYSTEMS	UE	5 credits
Adaptive and predictive controls	Matière	
Aeronautical systems	Matière	
Robotics: Modeling and Control	Matière	
Advanced Control TER	Matière	
Electrical Systems Control	Matière	
ADVANCED CRITICAL COMPUTING SYSTEMS	UE	5 credits
IT Security	Matière	
IT operational security	Matière	
Safety Testing and Evaluation	Matière	
Development of critical computer systems	Module	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1-Semestre 9	Bloc	
Anglais Scientifique	Matière	

Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Advanced Electromechanics (EMA)	Choix	30 credits
PHYSICS FOR MECHATRONICS	UE	5 credits
Advanced phenomena in electromechanical conversion	Matière	
Introduction to Magnetohydrodynamics	Matière	
Modeling of coupled phenomena	Matière	
NUMERICAL METHODS AND OPTIMISATION	UE	5 credits
Finite element numerical modelling	Matière	
Optimal control	Matière	
Optimised sizing of electrical machines	Matière	
Numerical modelling of machines	Matière	
DESIGN OF ELECTROMECHANICAL SYSTEMS	UE	5 credits
Design elements of static converters	Matière	
Mechanical design of actuators and generators	Matière	
Introduction to CAD	Matière	
Electric Generators	Matière	
ARCHITECTURES OF MECHATRONIC SYSTEMS	UE	5 credits
Multidimensional Systems	Matière	
Electric actuator control strategy	Matière	
TER Electric Actuator Control	Matière	
Electromagnetic compatibility	Matière	
Filtering estimation	Matière	
APPLIED MECHATRONICS	UE	5 credits
TER Advanced Control (EMA)	Matière	
Elastic metamaterials and actuators for space (Universeh)	Matière	
Winding techniques for electrical machines	Matière	
System Monitoring and Diagnostics	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1-Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	

Semestre 9 - Energy conversion and electrical networks (CERE)	Choix	30 credits
POWER SYSTEMS AND NETWORKS	UE	5 credits
System design	Matière	
Static Converters for power network conditioning	Matière	
Static Converters HVDC Networks	Matière	
CVS DESIGN	UE	5 credits
CVS Design	Matière	
CVS control	Matière	
Architecture and Control TER	Matière	
Power Electronic Technology	Matière	
STATIC CONVERTER AND ADVANCED SYSTEMS	UE	5 credits
CVS reliability	Matière	
EMC	Matière	
X. Levels	Matière	
Switching and functional integration	Matière	
ACTUATORS AND GENERATORS	UE	5 credits
Actuator control	Matière	
Actuator Control TER	Matière	
Multidimensional Systems	Matière	
SMARTGRIDS AND MICROGRIDS	UE	5 credits
Autonomous networks	Matière	
Sources, reversibility, storage	Matière	
Smart grids	Matière	
1/2 Themed days	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1 -Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Artificial Intelligence and Information Processing (IATI)	Choix	30 credits
SIGNAL AND APPLICATIONS	UE	5 credits
Antenna processing	Matière	
Automatic speech processing	Matière	
Audio et musique	Matière	
Satellite navigation	Matière	
AI AND HARDWARE	UE	5 credits
Edge computing	Matière	
Design of NN dedicated to embedded systems	Matière	
ELECTIVE TEACHING UNIT	Bloc	15 credits

ELECTIVE TEACHING UNIT SIA	Choix	
IMAGE - APPLICATIONS	UE	5 credits
Computational imaging	Matière	
Computational medical imaging	Matière	
Teledetection	Matière	
LEARNING AND DECISION	UE	5 credits
Data analysis	Matière	
Unsupervised learning	Matière	
Supervised learning	Matière	
VISION, AUGMENTED REALITY AND APPLICATIONS	UE	5 credits
Computer vision and augmented reality	Matière	
Transversal project	Matière	
ELECTIVE TEACHING UNIT TSE	Choix	
EMBEDDED SYSTEMS	UE	5 credits
System on Chip	Matière	
Architecture and hardware acceleration for DL	Matière	
AI AND SENSORS	UE	5 credits
Intelligent instrumentation chain technology	Matière	
Smart Sensor Project	Matière	
ADVANCED AI	UE	5 credits
Loosely supervised learning, RNN	Matière	
Data analysis 2 and classification	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1-Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - EcoEnergy (EE)	Choix	30 credits
SYSTEMIC DESIGN	UE	5 credits
System modeling in Bond Graph	Matière	
Eco-design and LCA	Matière	
Hydrogen supply chain	Matière	
Optimization of energy processes and systems	Matière	
SMART-GRIDS	UE	5 credits
Decentralized, embedded electrical networks	Matière	
Energy Hybridization of Systems	Matière	
Smart grids	Matière	
HYDROGEN VECTOR	UE	5 credits
Hydrogen production	Matière	
Hydrogen storage	Matière	

Fuel cells and hydrogen applications	Matière	
Electrochemistry	Matière	
RENEWABLE ENERGIES	UE	5 credits
Wind Power Systems	Matière	
Photovoltaic APP	Matière	
Low-Power Hydroelectric Installations	Matière	
NON ELECTRIC RENEWABLE ENERGIES	Élément	5 credits
	constitutif	
Biofuel systems	Matière	
Valorisation Biomasse Haute Température	Matière	
Renewable heat	Matière	
GENERAL TRAINING	UE	5 credits
Professional English-LV1 -Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
Themed Day: Energy and Sustainable Development	Matière	
Semestre 9 - Impact Entrepreneurship Low to Deep Tech 3EA	Choix	30 credits
Choix UE Hard Skills 3EA Parcours Impact Entrepreneurship	Bloc	
Choix UE Parc. InSys Parc. Impact Entrepreneurship	Choix	
ADVANCED DIGITAL ELECTRONICS	UE	5 credits
FPGA system design for signal processing	Matière	
Circuit testing and fault simulation	Matière	
POWER MANAGEMENT	UE	5 credits
Microprocessor Power Supply	Matière	
MOSFET Driver Circuits	Matière	
EMC for SMPS	Matière	
FEM Modeling of Integrated passive filters	Matière	
ADVANCED RADIOFREQUENCY ELECTRONICS	UE	5 credits
RF equipment	Matière	
MMIC	Matière	
MEMS	Matière	
ANALOG ELECTRONIC SYSTEMS IN RADIOFREQUENCIES	UE	5 credits
Optoelectronic Components and Circuits	Matière	
Filter Synthesis	Matière	
Integrated photonics	Matière	
Internet of Things	Matière	
DIGITAL SYSTEMS	UE	5 credits
Synthesis strategy	Matière	
EMC for integrated circuits	Matière	
System on Chip	Matière	
ANALOG AND DIGITAL SYSTEMS	UE	5 credits
ADC and DAC	Matière	
Space Embedded Systems Conferences	Matière	
Integration of instrumentation chains	Matière	

Reliability of embedded systems	Matière	
APPROFONDISSEMENT ANALOGIQUE	UE	5 credits
Introduction to Cadence Layout XL / Spectrum	Matière	
Analog ASIC project	Matière	
Choix UE Parc. SysCom Parc. Impact Entrepreneurship	Choix	
ADVANCED RADIOFREQUENCY ELECTRONICS	UE	5 credits
RF equipment	Matière	
MMIC	Matière	
MEMS	Matière	
PROPAGATION PHENOMENA AND RADAR	UE	5 credits
Actual propagation of electromagnetic waves	Matière	
Electromagnetic diffraction analysis / Radar equipment	Matière	
Radar project	Matière	
APPLIED PHYSICS AND NUMERICAL METHODS	UE	5 credits
Electromagnetism and multiscale devices	Matière	
Multiphysics Models	Matière	
Electromagnetism and nanoelectronics	Matière	
Synthesis of High Frequency Equivalent Electrical Circuits	Matière	
HIGH FREQUENCY EMBEDDED SYSTEMS	UE	5 credits
Microwave and Optical Sensors	Matière	
HF optoelectronic components and circuits	Matière	
Internet of Things	Matière	
Passive high frequency devices in waveguide technology	Matière	
MICROWAVE CIRCUITS AND ELECTROMAGNETIC COMPATIBILITY	UE	5 credits
Antenna networks	Matière	
Space antennas	Matière	
Aeronautical EMC 1	Matière	
Space Embedded Systems Conferences	Matière	
Microwave power amplifiers	Matière	
Aeronautical EMC 2	Matière	
MODELING	UE	5 credits
Variational methods for solving partial differential equations of physics	Matière	
Integral methods	Matière	
Plasma physics and applications	Matière	
Choix UE Parc. ACISE Parcours Impact Entrepreneurship	Choix	
SYSTEMS CONTROL, FILTERING AND DIAGNOSTIC	UE	5 credits
Filtering estimation	Matière	
System Monitoring and Diagnostics	Matière	
Multidimensional Systems	Matière	
SYSTEMS OPTIMISATION AND THEIR CONTROL	UE	5 credits
Robust control	Matière	
Optimal Control	Matière	
Combinatorial optimization	Matière	
Opti TER	Matière	
Linear programming and unimodularity	Matière	
Continuous optimization	Matière	

MODELING, ANALYSIS, SIMULATION OF DISCRETE SYSTEMS	UE	5 credits
Modeling and analysis of discrete systems	Matière	
Simulation of discrete event systems	Matière	
Planning and Scheduling	Matière	
Hybrid Dynamic Systems	Matière	
Flexible Workshop TER	Matière	
ADVANCED CONTROLLED SYSTEMS	UE	5 credits
Adaptive and predictive controls	Matière	
Aeronautical systems	Matière	
Robotics: Modeling and Control	Matière	
Advanced Control TER	Matière	
Electrical Systems Control	Matière	
ADVANCED CRITICAL COMPUTING SYSTEMS	UE	5 credits
IT Security	Matière	
IT operational security	Matière	
Safety Testing and Evaluation	Matière	
Development of critical computer systems	Module	
Choix UE Parc.CERE Parcours Impact Entrepreneurship	Choix	
POWER SYSTEMS AND NETWORKS	UE	5 credits
System design	Matière	
Static Converters for power network conditioning	Matière	
Static Converters HVDC Networks	Matière	
CVS DESIGN	UE	5 credits
CVS Design	Matière	
CVS control	Matière	
Architecture and Control TER	Matière	
Power Electronic Technology	Matière	
STATIC CONVERTER AND ADVANCED SYSTEMS	UE	5 credits
CVS reliability	Matière	
EMC	Matière	
X. Levels	Matière	
Switching and functional integration	Matière	
ACTUATORS AND GENERATORS	UE	5 credits
Actuator control	Matière	
Actuator Control TER	Matière	
Multidimensional Systems	Matière	
SMARTGRIDS AND MICROGRIDS	UE	5 credits
Autonomous networks	Matière	
Sources, reversibility, storage	Matière	
Smart grids	Matière	
1/2 Themed days	Matière	
Choix UE Parc. EMA Parcours Impact Entrepreneurship	Choix	
PHYSICS FOR MECHATRONICS	UE	5 credits
Advanced phenomena in electromechanical conversion	Matière	
Introduction to Magnetohydrodynamics	Matière	
Modeling of coupled phenomena	Matière	

NUMERICAL METHODS AND OPTIMISATION	UE	5 credits
Finite element numerical modelling	Matière	
Optimal control	Matière	
Optimised sizing of electrical machines	Matière	
Numerical modelling of machines	Matière	
DESIGN OF ELECTROMECHANICAL SYSTEMS	UE	5 credits
Design elements of static converters	Matière	
Mechanical design of actuators and generators	Matière	
Introduction to CAD	Matière	
Electric Generators	Matière	
ARCHITECTURES OF MECHATRONIC SYSTEMS	UE	5 credits
Multidimensional Systems	Matière	
Electric actuator control strategy	Matière	
TER Electric Actuator Control	Matière	
Electromagnetic compatibility	Matière	
Filtering estimation	Matière	
APPLIED MECHATRONICS	UE	5 credits
TER Advanced Control (EMA)	Matière	
Elastic metamaterials and actuators for space (Universeh)	Matière	
Winding techniques for electrical machines	Matière	
System Monitoring and Diagnostics	Matière	
Choix UE Parc. PN Parcours Impact Entrepreneurship	Choix	
METHODES NUMERIQUES ET OPTIMISATION-2	UE	5 credits
Optimal control	Matière	
High Performance Computing	Matière	
Simulation Numérique en optique	UE	
Topological Optimisation	Matière	
Finished volumes	Matière	
METHODES NUMERIQUES POUR LES PROBLEMES DE DIFFRACTION	UE	5 credits
Integral methods	Matière	
Electromagnetic diffraction analysis / Radar equipment	Matière	
Integral methods	Matière	
CEM ET MATHEMATIQUES APPLIQUEES	UE	5 credits
Multiphysics Models	Matière	
Variational methods for solving partial differential equations of physics	Matière	
Aeronautical EMC 1	Matière	
Electromagnetic compatibility	Matière	
High Performance Computing	Matière	
PHYSIQUE POUR LA MECATRONIQUE - PN	UE	5 credits
Plasma physics and applications	Matière	
Advanced phenomena in electromechanical conversion	Matière	
Modeling of coupled phenomena	Matière	
Introduction to Magnetohydrodynamics	Matière	
HIGH PERFORMANCE COMPUTING	UE	5 credits
Advanced Languages for programming	Matière	
Advanced Techniques for Scientific computing	Matière	

Meshing, Pre and Post Processing	Matière	
Choix UE Parc. EE Parcours Impact Entrepreneurship	Choix	
SYSTEMIC DESIGN	UE	5 credits
System modeling in Bond Graph	Matière	
Eco-design and LCA	Matière	
Hydrogen supply chain	Matière	
Optimization of energy processes and systems	Matière	
SMART-GRIDS	UE	5 credits
Decentralized, embedded electrical networks	Matière	
Energy Hybridization of Systems	Matière	
Smart grids	Matière	
RENEWABLE ENERGIES	UE	5 credits
Wind Power Systems	Matière	
Photovoltaic APP	Matière	
Low-Power Hydroelectric Installations	Matière	
GENERAL TRAINING	UE	5 credits
Professional English-LV1-Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
Themed Day: Energy and Sustainable Development	Matière	
Choix UE Parc. IATI Parcours Impact Entrepreneurship	Choix	
SIGNAL AND APPLICATIONS	UE	5 credits
Antenna processing	Matière	
Automatic speech processing	Matière	
Audio et musique	Matière	
Satellite navigation	Matière	
AI AND HARDWARE	UE	5 credits
Edge computing	Matière	
Design of NN dedicated to embedded systems	Matière	
IMAGE - APPLICATIONS	UE	5 credits
Computational imaging	Matière	
Computational medical imaging	Matière	
Teledetection	Matière	
LEARNING AND DECISION	UE	5 credits
Data analysis	Matière	
Unsupervised learning	Matière	
Supervised learning	Matière	
EMBEDDED SYSTEMS	UE	5 credits
System on Chip	Matière	
Architecture and hardware acceleration for DL	Matière	
AI AND SENSORS	UE	5 credits
Intelligent instrumentation chain technology	Matière	
Smart Sensor Project	Matière	
ADVANCED AI	UE	5 credits

Loosely supervised learning, RNN	Matière	
Data analysis 2 and classification	Matière	
VISION, AUGMENTED REALITY AND APPLICATIONS	UE	5 credits
Computer vision and augmented reality	Matière	
Transversal project	Matière	
SOFT SKILLS 1 - PARTNERSHIPS	UE	5 credits
UT ou TBS ou TSM 1 - module 18h	Matière	
UT ou TBS ou TSM 2 - module 18h	Matière	
UT ou TBS ou TSM 3 - module 18h	Matière	
SOFT SKILLS 2 - DESIGN THINKING	UE	5 credits
Design Thinking 1 - module 15h	Matière	
Design Thinking 2 - module 18h	Matière	
Professional Communication and English - module 21h	Matière	
SOFT SKILLS 3 - PROJET DEEP TECH & APPLICATIONS	UE	5 credits
PDT & CU 1 - module 18h	Matière	
PDT & CU 2 - module 18h	Matière	
PDT & CU 3 - module 18h	Matière	

Semestre 10 3EA à N7

	Nature	CM	TD	TP	Crédits
Projet Fin d'Etude 3EA sans Projet Long	UE				30 credits
Stage 2A 3EA	Matière				6 credits
PFE 3EA sans PL	Stage				24 credits
PFE 3EA avec Projet Long	UE				30 credits
Stage 2A 3EA	Matière				6 credits
Projet Long 3EA	UE				8 credits
Projet de Fin d'Etudes 3EA	UE				22 credits

Ingénieur ENSEEIHT Electronique et Génie Electrique (Apprentis)

Ingénieur ENSEEIHT par l'Apprentissage Electronique et Génie Electrique (En-Ge) 1ère année

Semestre 5-1A En-Ge FISA

	Nature	CM	TD	TP	Crédits
MATHEMATICS AND COMPUTER SCIENCE FOR ENGINEER	UE				4 credits
Math Review	UE				
Computer Science for Engineers	UE				
MATHEMATICS AND SCIENTIFIC COMPUTING	UE				4 credits
Real and Complex Analysis	UE				

Matlab-Simulink	UE	
APPLIED ELECTRICITY	UE	4 credits
Circuit basics	UE	
Single-phase systems	UE	
Single-phase transformer	UE	
ELECTRONIC COMPONENTS AND CIRCUITS	UE	4 credits
Electronic Components	UE	
Circuit theory	UE	
Basic Electronic Function Project	UE	
Analog circuits	UE	
SCIENCES HUMAINES SOCIALES ET JURIDIQUES-S5-FISA	UE	4 credits
Careers and Management 1	Matière	
Careers and Management 2	Matière	
Anglais Professionnel-S5-App	Matière	
COMPANY SEMESTER 5	UE	10 credits

Semestre 6-1A En-Ge FISA

	Nature	CM	TD	TP	Crédits
MATHEMATICS AND COMPUTER SCIENCE FOR ENGINEERS	UE				4 credits
Real analysis	UE				
Probabilities and Statistics	UE				
Calculator Structure	UE				
ANALOG ELECTRONICS	UE				4 credits
Analog Electronics Project	UE				
Electronic Functions	UE				
Analog circuits	UE				
LINEAR CIRCUITS AND SYSTEMS	UE				4 credits
Combinatorial and sequential logic	UE				
Filtering	UE				
Continuous Linear Systems	UE				
ELECTRICAL NETWORKS AND ENERGY CONVERSION	UE				4 credits
Introduction to Static Conversion	UE				
Switching power supply - Non-isolated structures	UE				
Introduction to Electromechanical Conversion	UE				
Three-phase networks	UE				
SCIENCES HUMAINES SOCIALES ET JURIDIQUES-S6-FISA	UE				4 credits
Anglais Professionnel-S6-FISA	Matière				
Careers and Management 1	Matière				
Careers and Management 2	Matière				
COMPANY SEMESTER 6	UE				10 credits

Ingénieur ENSEEIHT Electronique et GE 2ème année (Apprentis)

Semestre 7-2A-En-Ge FISA

	Nature	CM	TD	TP	Crédits
MATHEMATICS AND COMPUTER SYSTEMS	UE				4 credits
Partial Differential Equation	UE				
Modeling and Development of Industrial Systems: Programmed Logic	UE				
Modeling and Development of Industrial Systems—Object-Oriented Modeling and Development	UE				
DIGITAL SYSTEMS AND DIGITAL SIGNAL PROCESSING	UE				4 credits
Microprocessors	UE				
Digital Signal Processing	UE				
STATIC CONVERSION AND THEIR CONTROL	UE				4 credits
Design and implementation of Static Converters	UE				
Closed-loop control of continuous linear systems	UE				
ELECTIVE TEACHING UNIT	UE				4 credits
OPTION EN: MATERIAL DESCRIPTION LANGUAGES and TR	UE				4 credits
Digital design in VHDL	UE				
VHDL Project	UE				
DSP, Digital Filtering	Élément constitutif				
OPTION ENERGY: ELECTROMECHANIC CONVERSION	Matière				4 credits
Machine Modeling	UE				
Principles and structures of electrical machines	LV2 facultative				
SCIENCES HUMAINES SOCIALES ET JURIDIQUES-S7-FISA	UE				4 credits
Anglais Professionnel-S7-App	Matière				
Careers and Management 1- App Sem7	Matière				
Careers and Management 2- APP Sem7	Matière				
COMPANY SEMESTER 7	UE				10 credits

Semestre 8-2A-En-Ge FISA

	Nature	CM	TD	TP	Crédits
ELECTIVE OPTIONS	UE				16 credits
ENERGY OPTION	UE				16 credits
ELECTRIC SYSTEM	Choix				4 credits
Machine/converter association and their control	UE				
Analysis and modeling of a vehicle through reverse engineering	Stage				
AUTOMATIC AND TR	UE				4 credits
Space State	UE				
sampled linear systems	UE				

Real Time Informatics	UE	
Non Linear Systems	UE	
ECO-ENERGY	UE	4 credits
FACTS Introduction	UE	
Renewable Energies	UE	
POWER ELECTRONICS	UE	4 credits
Inverter	UE	
Switching Mechanisms	UE	
Thermics	UE	
ELECTRONIC OPTION	UE	16 credits
ANALOG CIRCUIT DESIGN	Choix	4 credits
Linear Circuits	UE	
Non Linear Circuits	UE	
Analog Electronics Project	UE	
PROPAGATION AND RADIATION	LV2	4 credits
	facultative	
Transmission Lines	UE	
Electromagnetism and guided propagation	UE	
Radiation and Antennas	UE	
OPTOELECTRONICS AND RADIOFREQUENCIES	UE	4 credits
Optoelectronics	UE	
RF Circuit	UE	
MMIC	UE	
RF-Digital Project	UE	
INTEGRATION	UE	4 credits
MOS	UE	
Front-End instrumentation	UE	
Design and FPGA	UE	
SCIENCES HUMAINES SOCIALES ET JURIDIQUES-S8-FISA	UE	4 credits
Anglais Professionnel-S8-App	Matière	
Careers and Management 1	Matière	
Careers and Management 2	Matière	
COMPANY SEMESTER 8	UE	10 credits

Ingénieur ENSEEIHT Electronique et GE 3ème année (Apprentis)

	Nature	CM	TD	TP	Crédits
Semestre 9 FISA (manuel)					
	Nature	CM	TD	TP	Crédits
Semestre 9 - Systems Integration (INSYS)	Choix				30 credits
ANALOG ELECTRONIC SYSTEMS IN RADIOFREQUENCIES	UE				5 credits
Optoelectronic Components and Circuits	Matière				
Filter Synthesis	Matière				

Integrated photonics	Matière	
Internet of Things	Matière	
DIGITAL SYSTEMS	UE	5 credits
Synthesis strategy	Matière	
EMC for integrated circuits	Matière	
System on Chip	Matière	
ANALOG AND DIGITAL SYSTEMS	UE	5 credits
ADC and DAC	Matière	
Space Embedded Systems Conferences	Matière	
Integration of instrumentation chains	Matière	
Reliability of embedded systems	Matière	
1st ELECTIVE TEACHING UNIT	UE	5 credits
ADVANCED DIGITAL ELECTRONICS	UE	5 credits
FPGA system design for signal processing	Matière	
Circuit testing and fault simulation	Matière	
ADVANCED ANALOG ELECTRONICS	UE	5 credits
Introduction to Cadence Layout XL / Spectrum	Matière	
Analog ASIC project	Matière	
2nd ELECTIVE TEACHING UNIT	UE	5 credits
POWER MANAGEMENT	UE	5 credits
Microprocessor Power Supply	Matière	
MOSFET Driver Circuits	Matière	
EMC for SMPS	Matière	
FEM Modeling of Integrated passive filters	Matière	
ADVANCED RADIOFREQUENCY ELECTRONICS	UE	5 credits
RF equipment	Matière	
MMIC	Matière	
MEMS	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1 -Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Communication Systems (SYSCOM)	Choix	30 credits
APPLIED PHYSICS AND NUMERICAL METHODS	UE	5 credits
Electromagnetism and multiscale devices	Matière	
Multiphysics Models	Matière	
Electromagnetism and nanoelectronics	Matière	
Synthesis of High Frequency Equivalent Electrical Circuits	Matière	
HIGH FREQUENCY EMBEDDED SYSTEMS	UE	5 credits

Microwave and Optical Sensors	Matière	
HF optoelectronic components and circuits	Matière	
Internet of Things	Matière	
Passive high frequency devices in waveguide technology	Matière	
MICROWAVE CIRCUITS AND ELECTROMAGNETIC COMPATIBILITY	UE	5 credits
Antenna networks	Matière	
Space antennas	Matière	
Aeronautical EMC 1	Matière	
Space Embedded Systems Conferences	Matière	
Microwave power amplifiers	Matière	
Aeronautical EMC 2	Matière	
PROPAGATION PHENOMENA AND RADAR	UE	5 credits
Actual propagation of electromagnetic waves	Matière	
Electromagnetic diffraction analysis / Radar equipment	Matière	
Radar project	Matière	
ELECTIVE TEACHING UNIT	Choix	5 credits
ADVANCED RADIOFREQUENCY ELECTRONICS	UE	5 credits
RF equipment	Matière	
MMIC	Matière	
MEMS	Matière	
MODELING	UE	5 credits
Variational methods for solving partial differential equations of physics	Matière	
Integral methods	Matière	
Plasma physics and applications	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1 -Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Control Architecture Computer Science and Embedded Systems (ACISE)	Choix	30 credits
SYSTEMS CONTROL, FILTERING AND DIAGNOSTIC	UE	5 credits
Filtering estimation	Matière	
System Monitoring and Diagnostics	Matière	
Multidimensional Systems	Matière	
SYSTEMS OPTIMISATION AND THEIR CONTROL	UE	5 credits
Robust control	Matière	
Optimal Control	Matière	
Combinatorial optimization	Matière	
Opti TER	Matière	

Linear programming and unimodularity	Matière	
Continuous optimization	Matière	
MODELING, ANALYSIS, SIMULATION OF DISCRETE SYSTEMS	UE	5 credits
Modeling and analysis of discrete systems	Matière	
Simulation of discrete event systems	Matière	
Planning and Scheduling	Matière	
Hybrid Dynamic Systems	Matière	
Flexible Workshop TER	Matière	
ADVANCED CONTROLLED SYSTEMS	UE	5 credits
Adaptive and predictive controls	Matière	
Aeronautical systems	Matière	
Robotics: Modeling and Control	Matière	
Advanced Control TER	Matière	
Electrical Systems Control	Matière	
ADVANCED CRITICAL COMPUTING SYSTEMS	UE	5 credits
IT Security	Matière	
IT operational security	Matière	
Safety Testing and Evaluation	Matière	
Development of critical computer systems	Module	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1 -Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Advanced Electromechanics (EMA)	Choix	30 credits
PHYSICS FOR MECHATRONICS	UE	5 credits
Advanced phenomena in electromechanical conversion	Matière	
Introduction to Magnetohydrodynamics	Matière	
Modeling of coupled phenomena	Matière	
NUMERICAL METHODS AND OPTIMISATION	UE	5 credits
Finite element numerical modelling	Matière	
Optimal control	Matière	
Optimised sizing of electrical machines	Matière	
Numerical modelling of machines	Matière	
DESIGN OF ELECTROMECHANICAL SYSTEMS	UE	5 credits
Design elements of static converters	Matière	
Mechanical design of actuators and generators	Matière	
Introduction to CAD	Matière	
Electric Generators	Matière	
ARCHITECTURES OF MECHATRONIC SYSTEMS	UE	5 credits

Multidimensional Systems	Matière	
Electric actuator control strategy	Matière	
TER Electric Actuator Control	Matière	
Electromagnetic compatibility	Matière	
Filtering estimation	Matière	
APPLIED MECHATRONICS	UE	5 credits
TER Advanced Control (EMA)	Matière	
Elastic metamaterials and actuators for space (Universeh)	Matière	
Winding techniques for electrical machines	Matière	
System Monitoring and Diagnostics	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1-Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Energy conversion and electrical networks (CERE)	Choix	30 credits
POWER SYSTEMS AND NETWORKS	UE	5 credits
System design	Matière	
Static Converters for power network conditioning	Matière	
Static Converters HVDC Networks	Matière	
CVS DESIGN	UE	5 credits
CVS Design	Matière	
CVS control	Matière	
Architecture and Control TER	Matière	
Power Electronic Technology	Matière	
STATIC CONVERTER AND ADVANCED SYSTEMS	UE	5 credits
CVS reliability	Matière	
EMC	Matière	
X. Levels	Matière	
Switching and functional integration	Matière	
ACTUATORS AND GENERATORS	UE	5 credits
Actuator control	Matière	
Actuator Control TER	Matière	
Multidimensional Systems	Matière	
SMARTGRIDS AND MICROGRIDS	UE	5 credits
Autonomous networks	Matière	
Sources, reversibility, storage	Matière	
Smart grids	Matière	
1/2 Themed days	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits

Professional English-LV1 -Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - EcoEnergy (EE)	Choix	30 credits
SYSTEMIC DESIGN	UE	5 credits
System modeling in Bond Graph	Matière	
Eco-design and LCA	Matière	
Hydrogen supply chain	Matière	
Optimization of energy processes and systems	Matière	
SMART-GRIDS	UE	5 credits
Decentralized, embedded electrical networks	Matière	
Energy Hybridization of Systems	Matière	
Smart grids	Matière	
HYDROGEN VECTOR	UE	5 credits
Hydrogen production	Matière	
Hydrogen storage	Matière	
Fuel cells and hydrogen applications	Matière	
Electrochemistry	Matière	
RENEWABLE ENERGIES	UE	5 credits
Wind Power Systems	Matière	
Photovoltaic APP	Matière	
Low-Power Hydroelectric Installations	Matière	
NON ELECTRIC RENEWABLE ENERGIES	Élément	5 credits
	constitutif	
Biofuel systems	Matière	
Valorisation Biomasse Haute Température	Matière	
Renewable heat	Matière	
GENERAL TRAINING	UE	5 credits
Professional English-LV1 -Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
Themed Day: Energy and Sustainable Development	Matière	
METHODES NUMERIQUES ET OPTIMISATION-2	UE	5 credits
Optimal control	Matière	
High Performance Computing	Matière	
Simulation Numérique en optique	UE	

Topological Optimisation	Matière	
Finished volumes	Matière	
METHODES NUMERIQUES POUR LES PROBLEMES DE DIFFRACTION	UE	5 credits
Integral methods	Matière	
Electromagnetic diffraction analysis / Radar equipment	Matière	
Integral methods	Matière	
CEM ET MATHEMATIQUES APPLIQUEES	UE	5 credits
Multiphysics Models	Matière	
Variational methods for solving partial differential equations of physics	Matière	
Aeronautical EMC 1	Matière	
Electromagnetic compatibility	Matière	
High Performance Computing	Matière	
PHYSIQUE POUR LA MECATRONIQUE - PN	UE	5 credits
Plasma physics and applications	Matière	
Advanced phenomena in electromechanical conversion	Matière	
Modeling of coupled phenomena	Matière	
Introduction to Magnetohydrodynamics	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1-Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
HIGH PERFORMANCE COMPUTING	UE	5 credits
Advanced Languages for programming	Matière	
Advanced Techniques for Scientific computing	Matière	
Meshing, Pre and Post Processing	Matière	

Semestre 9 Parcours Physique Numérique-3A-3EA

	Nature	CM	TD	TP	Crédits
OUTILS NUMERIQUES POUR LA PROPAGATION	UE				5 credits
PHYSIQUE ET OPTIMISATION	UE				5 credits
Physique et modélisation	Matière				
METHODES NUMERIQUES	UE				5 credits
Projet Méthode numérique et calcul haute performance	Matière				
HIGH PERFORMANCE COMPUTING	UE				5 credits

Advanced Languages for programming
 Advanced Techniques for Scientific computing
 Meshing, Pre and Post Processing

Matière
 Matière
 Matière

Semestre 10 3EA à N7

	Nature	CM	TD	TP	Crédits
Projet Fin d'Etude 3EA sans Projet Long	UE				30 credits
Stage 2A 3EA	Matière				6 credits
PFE 3EA sans PL	Stage				24 credits
PFE 3EA avec Projet Long	UE				30 credits
Stage 2A 3EA	Matière				6 credits
Projet Long 3EA	UE				8 credits
Projet de Fin d'Etudes 3EA	UE				22 credits

Ingénieur ENSEEIHT Electronique et Génie Electrique

Ingénieur ENSEEIHT Electronique et Génie Electrique



ECTS
180 credits



Duration
3 ans



Teaching
organization
Formation
professionnelle,
Formation
initiale

Program

Ingénieur ENSEEIHT Electronique et Génie électrique (En-Ge) 1ère année

Semestre 5 3EA-FISE

	Nature	CM	TD	TP	Crédits
Integration and probabilities	UE				5 credits
Integration	UE				
Complex Variable	UE				
Probabilities	UE				
Introduction to Algorithmic, Programming and Computer Architecture	UE				5 credits
Algorithms and Imperative Programming	UE				
Architecture and Assembler-programming	UE				
Digital Systems Design	UE				5 credits
Theoretical Approach of combinational and sequential logic	UE				
Digital Functions and Technologies	UE				
Project : Design of sequential and combinatoria Digital units	UE				
Fundamental Circuit Theory	UE				5 credits
Electric Circuits Analysis Methods	UE				
Instrumentation and Power Circuits	UE				
Circuits labs	UE				
Physics for Electrical Engineering	UE				5 credits
Electromagnetism	UE				
Material Physics	UE				
Propagation in Transmission Lines	UE				
Soft and Human Skills	UE				5 credits
Anglais	Matière				
Second language	Choix				
Spanish	Matière				
Portuguese	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
French as a Foreign Language	Matière				
LSF - S5	Matière				
Sports	Matière				
Leadership and management	Matière				

Semestre 6-3EA-FISE

	Nature	CM	TD	TP	Crédits
Numerical Analysis and Statistics	UE				5 credits
Differential Calculation and Optimisation	UE				
Solving PDEs using finite differences	LV2				
Statistics	UE				
Signal and Control	UE				5 credits
Signal Processing	UE				
Digital Signal Processing	UE				
Continuous Linear Systems Control	UE				
Electric circuits and systems	UE				5 credits
Modeling by physical analogies & analysis	UE				
Op-amps and Compensation	UE				
Course (1 choice out of 2)	UE				
Advanced Amplifier Systems	UE				
Modeling of magnetic circuits	EC				
Components and Architecture	UE				5 credits
Semiconductors Physics and PN Junctions	UE				
Signal and Power Transistors	UE				
Course (1 choice out of 2)	UE				
Transistors Amplifier Circuits	UE				
Introduction to Static Conversion	UE				
Teaching unit (1 choice out of 3)	UE				5 credits
CONNECTED OBJECTS	UE				5 credits
Connected Objects	UE				
Connected Objects	UE				
ELECTRICAL PLANE	UE				5 credits
Airplane Electrical Networks	UE				
Basic Structures for C/A and A/C Conversion	UE				
Electromecanic conversion	UE				
Airplane Electrical Networks	UE				
Basic Structures for C/A and A/C Conversion	UE				
Electromecanic conversion	UE				
INTRODUCTION TO TELECOMMUNICATIONS	UE				5 credits
Introduction to Digital Communications	Matière				
Introduction to networks	Matière				
SOFT AND HUMAN SKILLS 2	UE				5 credits
Elément à choix UE SHS S6 FISE	Élément constitutif				
English	Matière				
Sports	Matière				
Leadership Part 1 - S6	Matière				

Leadership Part 2 - S6	Matière
Entrepreneurship Part 1 - S6	Matière
Entrepreneurship Part 2 - S6	Matière
Citizenship Part 1 - S6	Matière
Citizenship Part 2 - S6	Matière
Agile methods	Matière
Managership P1-S6	Matière
Managership P2-S6	Matière
Spanish	Matière
Portuguese	Matière
Chinese	Matière
Italian	Matière
Japanese	Matière
Russian	Matière
German	Matière
French as a Foreign Language	Matière
FSL - S6	Matière

Ingénieur ENSEEIHT Electronique et Génie électrique (En-Ge) 2ème année

Semestre 7 - Parcours à choix (manuel)

	Nature	CM	TD	TP	Crédits
Semestre 7 - Electronics (EN)	Choix				30 credits
RADIOFREQUENCY ANALOG ELECTRONICS	UE				5 credits
RF Active Circuits	UE				
PLL and Oscillators	UE				
Analog Filtering	UE				
TP Advanced Design System (ADS)	UE				
LOW FREQUENCY ANALOG ELECTRONICS	UE				5 credits
Amplification classes	UE				
Analog Project	UE				
DIGITAL ELECTRONICS	UE				5 credits
VHDL	UE				
Front-End instrumentation	UE				
ELECTROMAGNETIC PROPAGATION	UE				5 credits
Guided propagation	UE				
Ideal Passive Circuits	UE				
Transmission Lines	UE				
INFORMATION PROCESSING	UE				5 credits
Random Signals	UE				
Object-Oriented Programming (POO)	UE				
Microprocessor	UE				
SOFT AND HUMAN SKILLS	UE				5 credits
Professional English 2.1 : Presentations	Matière				

2nd language	Bloc	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
French as a Foreign Language	Matière	
LSF - S7	Matière	
Sports	Matière	
Leadership & Management	Matière	
Semestre 7 - Electronics, Electrical Energy and Simulations (EEES)	Choix	30 credits
ELECTROMAGNETIC PROPAGATION	UE	5 credits
Guided propagation	UE	
Ideal Passive Circuits	UE	
Transmission Lines	UE	
COMPUTER SCIENCE AND ANALOG FILTERING	UE	5 credits
Analog Filtering	UE	
Object-Oriented Programming (POO)	UE	
Reliability of numerical calculations	Matière	
SCIENTIFIC COMPUTING FOR ELECTRICAL ENGINEERING	UE	5 credits
Random Signals	UE	
Numerical analysis	Matière	
Numerical Methods for PDE	Matière	
POWER ELECTRONIC COMPONENTS AND MECATRONIC	UE	5 credits
Electro-megneto-thermal modeling and simulation of power electronic components	Matière	
Principle and structure of machines	Module	
ELECTRICAL MACHINE MODELING AND NUMERICAL SIMULATION	UE	5 credits
Electromagnetic modeling of machines	UE	
Numerical experiences	Matière	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.1 : Presentations	Matière	
2nd language	Bloc	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
French as a Foreign Language	Matière	
LSF - S7	Matière	
Sports	Matière	
Leadership & Management	Matière	

Semestre 7 - Energy (NRJ)

Choix 30 credits

COMPUTER SYSTEMS ARCHITECTURE AND DEVELOPMENT	UE	5 credits
Object-oriented design and programming	UE	
Principles of Operating Systems	UE	
Computer Architecture	UE	
STATIC CONVERTER SYNTHESIS AND DESIGN	UE	5 credits
Energy approaches to the design of static converters	UE	
Static Converter Design Project	UE	
ELECTRICAL MACHINES	UE	5 credits
Electromagnetic modeling of machines	UE	
Principle and structure of machines	Module	
ELECTRICAL NETWORKS	UE	5 credits
Energy of today and tomorrow	UE	
Electrical energy technology	UE	
Electrical energy transmission network	UE	
Modulation and filtering of voltage inverters	UE	
LINEAR SYSTEMS CONTROL	UE	5 credits
Identification	UE	
Sampled systems	UE	
Synthesis of correctors and control architectures	UE	
Automatic Tutorials	UE	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.1 : Presentations	Matière	
2nd language	Bloc	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
French as a Foreign Language	Matière	
LSF - S7	Matière	
Sports	Matière	
Leadership & Management	Matière	

Semestre 8 - Parcours à choix (manuel)

	Nature	CM	TD	TP	Crédits
Semestre 8 - Systems Integration (INSYS)	Choix				30 credits
FROM SILICON TO INTEGRATED CIRCUIT	UE				5 credits
From Silicon to Integrated Circuits	UE				
MICROWAVES	UE				5 credits
HFSS	UE				
Antennas Project	UE				

Microwave Project	UE	
Microwave Tutorials	Matière	
DIGITAL SYSTEMS ARCHITECTURE	UE	5 credits
Synchronous design of digital systems	Matière	
FPGA technology	UE	
Verification	EC	
CIRCUITS AND OPTOELECTRONICS	UE	5 credits
Analog integrated circuits	UE	
Optoelectronics	UE	
Optoelectronics Tutorials	Matière	
NANOSATELLITE SYSTEMS	UE	5 credits
Cubesat platform: an introduction	Matière	
Payload Sizing	Matière	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.2 : Debates	Matière	
Second language	Choix	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
french (as a foreign language)	Matière	
LSF - S8	Matière	
Sports	Matière	
Careers and Management - Sem.8	Choix	
Leadership	Matière	
Entrepreneurship	Matière	
Citizenship	Matière	
Managership-S8	Matière	
Semestre 8 -Communication Systems (SYSCOM)	Choix	30 credits
APPLIED MATHEMATICS	UE	5 credits
Advanced linear algebra	UE	
Hilbertian analysis	UE	
Optimisation under constraints	Matière	
PHYSICAL PHENOMENA AND MODELING	UE	5 credits
Electromagnetic radiation and antennas	Matière	
Physical analysis of guiding structures	UE	
Project: Modelling of structures in EM	Matière	
MICROWAVE DEVICES	UE	5 credits
Planar antennas and radiating apertures	UE	
Microwave Project	UE	
Microwave Tutorials	Matière	
SCIENTIFIC COMPUTING AND OPTOELECTRONICS	UE	5 credits
Finite elements for electromagnetism	Matière	

Programming for scientific computing	Matière	
Optoelectronics	UE	
Optoelectronics Tutorials	Matière	
NANOSATELLITE SYSTEMS	UE	5 credits
Cubesat platform: an introduction	Matière	
Payload Sizing	Matière	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.2 : Debates	Matière	
Second language	Choix	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
french (as a foreign language)	Matière	
LSF - S8	Matière	
Sports	Matière	
Careers and Management - Sem.8	Choix	
Leadership	Matière	
Entrepreneurship	Matière	
Citizenship	Matière	
Managership-S8	Matière	
Semestre 8 - Numerical Physics (PN)	Choix	30 credits
MECATRONICS	UE	5 credits
Materials	UE	
Smart Electroactive Materials	UE	
Modeling of electromagnetic systems using analytical calculations	UE	
Thermal and Fluid Mechanics	UE	
NUMERICAL PROJECTS	UE	5 credits
Numerical Project	Matière	
SCIENTIFIC COMPUTING	UE	5 credits
Numerical simulation in optics	UE	
Numerical analysis 2	Matière	
Programming for scientific computing	Matière	
Optimal design of a rocket nozzle actuator	UE	
Finite elements for electromagnetism	Matière	
PHYSICAL PHENOMENA AND MODELING	UE	5 credits
Electromagnetic radiation and antennas	Matière	
Physical analysis of guiding structures	UE	
Project: Modelling of structures in EM	Matière	
APPLIED MATHEMATICS	UE	5 credits
Advanced linear algebra	UE	
Hilbertian analysis	UE	
Optimisation under constraints	Matière	

SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.2 : Debates	Matière	
Second language	Choix	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
french (as a foreign language)	Matière	
LSF - S8	Matière	
Sports	Matière	
Careers and Management - Sem.8	Choix	
Leadership	Matière	
Entrepreneurship	Matière	
Citizenship	Matière	
Managership-S8	Matière	
Semestre 8 - Real-time automated systems (SATR)	Choix	30 credits
CONTROLLED, NON LINEAR SYSTEMS	UE	5 credits
State space	UE	
Introduction to Non-linear control	UE	
Non-linear control	UE	
Automatic Tutorials	UE	
DIGITAL CONTROL	UE	5 credits
Digital control	UE	
Digital Control Project	UE	
Industrial automation	UE	
Automatic Control Systems Tutorials	UE	
ELECTRICAL SYSTEM ARCHITECTURES AND CONTROLS	UE	5 credits
Electric vehicle motor sizing / CVS-Machines design elements	LV2	
	facultative	
Converter control	UE	
Machine control	UE	
ZOE powertrain project	UE	
DISCRETE AND SAMPLED EVENT SYSTEMS	UE	5 credits
Polynomial control	UE	
Graphs and Scheduling	UE	
Identification (recursive methods)	UE	
Automatic Tutorials	UE	
Petri network	UE	
NETWORK AND REAL-TIME SYSTEMS ENGINEERING	UE	5 credits
Distributed Computer Systems	UE	
Industrial networks	UE	
Real-time systems	UE	
SOFT AND HUMAN SKILLS	UE	5 credits

Professional English 2.2 : Debates	Matière	
Second language	Choix	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
french (as a foreign language)	Matière	
LSF - S8	Matière	
Sports	Matière	
Careers and Management - Sem.8	Choix	
Leadership	Matière	
Entrepreneurship	Matière	
Citizenship	Matière	
Managership-S8	Matière	
Semestre 8 - Mechatronic System (SM)	Choix	30 credits
CONTROLLED, NON LINEAR SYSTEMS	UE	5 credits
State space	UE	
Introduction to Non-linear control	UE	
Non-linear control	UE	
Automatic Tutorials	UE	
DIGITAL CONTROL	UE	5 credits
Digital control	UE	
Digital Control Project	UE	
Industrial automation	UE	
Automatic Control Systems Tutorials	UE	
ELECTRICAL SYSTEM ARCHITECTURES AND CONTROLS	UE	5 credits
Electric vehicle motor sizing / CVS-Machines design elements	LV2	
	facultative	
Converter control	UE	
Machine control	UE	
ZOE powertrain project	UE	
ACTUATION MATERIALS	UE	5 credits
Materials	UE	
Smart Electroactive Materials	UE	
Finite element methods	UE	
Lagrangian approach to electromechanical systems	Matière	
ANALYTICAL AND PHYSICAL TOOLS FOR MECHATRONICS	UE	5 credits
System optimization and optimal design	UE	
Optimal design of a rocket nozzle actuator	UE	
Modeling of electromagnetic systems using analytical calculations	UE	
Thermal and Fluid Mechanics	UE	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.2 : Debates	Matière	

Second language	Choix	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	
Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
french (as a foreign language)	Matière	
LSF - S8	Matière	
Sports	Matière	
Careers and Management - Sem.8	Choix	
Leadership	Matière	
Entrepreneurship	Matière	
Citizenship	Matière	
Managership-S8	Matière	
Semestre 8 - Electrical systems of the future (SEF)	Choix	30 credits
CONTROLLED, NON LINEAR SYSTEMS	UE	5 credits
State space	UE	
Introduction to Non-linear control	UE	
Non-linear control	UE	
Automatic Tutorials	UE	
DIGITAL CONTROL	UE	5 credits
Digital control	UE	
Digital Control Project	UE	
Industrial automation	UE	
Automatic Control Systems Tutorials	UE	
ELECTRICAL SYSTEM ARCHITECTURES AND CONTROLS	UE	5 credits
Electric vehicle motor sizing / CVS-Machines design elements	LV2	
	facultative	
Converter control	UE	
Machine control	UE	
ZOE powertrain project	UE	
IMPLEMENTATION OF SWITCHING CELLS	UE	5 credits
Switching Mechanisms in Static Converters	UE	
Thermal	UE	
Static Converter close control project	UE	
RENEWABLE ENERGIES AND FACTS	UE	5 credits
Introduction to FACTS	UE	
Renewable energy: wind and solar power	UE	
SOFT AND HUMAN SKILLS	UE	5 credits
Professional English 2.2 : Debates	Matière	
Second language	Choix	
Spanish	Matière	
Spanish	Matière	
Chinese	Matière	

Italian	Matière	
Japanese	Matière	
Russian	Matière	
German	Matière	
french (as a foreign language)	Matière	
LSF - S8	Matière	
Sports	Matière	
Careers and Management - Sem.8	Choix	
Leadership	Matière	
Entrepreneurship	Matière	
Citizenship	Matière	
Managership-S8	Matière	
Semestre 8 - Artificial intelligence for information processing (IATI)	Choix	30 credits
APPLIED MATHEMATICS	UE	5 credits
Advanced linear algebra	UE	
Hilbertian analysis	UE	
Optimisation under constraints	Matière	
DIGITAL SYSTEM ARCHITECTURE	UE	5 credits
Synchronous design of digital systems	Matière	
FPGA technology	UE	
DSP	UE	
IMAGE AND SIGNAL PROCESSING MODELING	UE	5 credits
Image processing	UE	
Image Project	Matière	
Modeling	UE	
Elective Course: Advanced Study in IATI	Bloc	10 credits
Advanced Study SIA	Choix	
SIGNAL ADVANCED METHODS	UE	5 credits
Signal representation and analysis	Matière	
Optimal filtering	Matière	
Multivariate analysis	Matière	
Inverse problems	Matière	
AI FUNDAMENTALS	UE	5 credits
Information Theory	Matière	
Introduction to Deep Learning	Matière	
Statistics - advanced methods	Matière	
Computational statistics	Matière	
Advanced Study TSE	Choix	
SIGNAL ADVANCED METHODS	UE	5 credits
Signal representation and analysis	Matière	
Optimal filtering	Matière	
Multivariate analysis	Matière	
AI INTRODUCTION	UE	5 credits
Introduction to Deep Learning	Matière	
General AI integration: first hardware integration	Matière	
SOFT AND HUMAN SKILLS	UE	5 credits

Professional English 2.2 : Debates
 Second language
 Spanish
 Spanish
 Chinese
 Italian
 Japanese
 Russian
 German
 french (as a foreign language)
 LSF - S8
 Sports
 Careers and Management - Sem.8
 Leadership
 Entrepreneurship
 Citizenship
 Managership-S8

Matière
 Choix
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Semestre 7 3EA FISE Parcours - EEES

Semestre 7 3EA FISE Parcours Energie

Ingénieur ENSEIHT Electronique et Génie électrique (En-Ge) 3ème année

Semestre 9 - Parcours à choix (manuel)

	Nature	CM	TD	TP	Crédits
Semestre 9 - Systems Integration (INSYS)	Choix				30 credits
ANALOG ELECTRONIC SYSTEMS IN RADIOFREQUENCIES	UE				5 credits
Optoelectronic Components and Circuits	Matière				
Filter Synthesis	Matière				
Integrated photonics	Matière				
Internet of Things	Matière				
DIGITAL SYSTEMS	UE				5 credits
Synthesis strategy	Matière				
EMC for integrated circuits	Matière				
System on Chip	Matière				
ANALOG AND DIGITAL SYSTEMS	UE				5 credits
ADC and DAC	Matière				
Space Embedded Systems Conferences	Matière				
Integration of instrumentation chains	Matière				
Reliability of embedded systems	Matière				
1st ELECTIVE TEACHING UNIT	UE				5 credits
ADVANCED DIGITAL ELECTRONICS	UE				5 credits
FPGA system design for signal processing	Matière				

Circuit testing and fault simulation	Matière	
ADVANCED ANALOG ELECTRONICS	UE	5 credits
Introduction to Cadence Layout XL / Spectrum	Matière	
Analog ASIC project	Matière	
2nd ELECTIVE TEACHING UNIT	UE	5 credits
POWER MANAGEMENT	UE	5 credits
Microprocessor Power Supply	Matière	
MOSFET Driver Circuits	Matière	
EMC for SMPS	Matière	
FEM Modeling of Integrated passive filters	Matière	
ADVANCED RADIOFREQUENCY ELECTRONICS	UE	5 credits
RF equipment	Matière	
MMIC	Matière	
MEMS	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1-Semestre 3	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Communication Systems (SYSCOM)	Choix	30 credits
APPLIED PHYSICS AND NUMERICAL METHODS	UE	5 credits
Electromagnetism and multiscale devices	Matière	
Multiphysics Models	Matière	
Electromagnetism and nanoelectronics	Matière	
Synthesis of High Frequency Equivalent Electrical Circuits	Matière	
HIGH FREQUENCY EMBEDDED SYSTEMS	UE	5 credits
Microwave and Optical Sensors	Matière	
HF optoelectronic components and circuits	Matière	
Internet of Things	Matière	
Passive high frequency devices in waveguide technology	Matière	
MICROWAVE CIRCUITS AND ELECTROMAGNETIC COMPATIBILITY	UE	5 credits
Antenna networks	Matière	
Space antennas	Matière	
Aeronautical EMC 1	Matière	
Space Embedded Systems Conferences	Matière	
Microwave power amplifiers	Matière	
Aeronautical EMC 2	Matière	
PROPAGATION PHENOMENA AND RADAR	UE	5 credits
Actual propagation of electromagnetic waves	Matière	
Electromagnetic diffraction analysis / Radar equipment	Matière	

Radar project	Matière	
ELECTIVE TEACHING UNIT	Choix	5 credits
ADVANCED RADIOFREQUENCY ELECTRONICS	UE	5 credits
RF equipment	Matière	
MMIC	Matière	
MEMS	Matière	
MODELING	UE	5 credits
Variational methods for solving partial differential equations of physics	Matière	
Integral methods	Matière	
Plasma physics and applications	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1-Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Computational Physics (PN)	Choix	30 credits
ENVIRONMENT FOR INTENSIVE COMPUTING	UE	5 credits
BES langages avancés (C++, Phytion)	Matière	
Environnement Logiciel du Calcul Scientifique	Matière	
Techniques de génération maillage, pré/post processing	Matière	
NUMERICAL METHODS FOR DIFFRACTION PROBLEMS	UE	5 credits
Integral methods	Matière	
Electromagnetic diffraction analysis / Radar equipment	Matière	
PHYSICS FOR MECHATRONICS	UE	5 credits
Plasma physics and applications	Matière	
Advanced phenomena in electromechanical conversion	Matière	
Modeling of coupled phenomena	Matière	
Introduction to Magnetohydrodynamics	Matière	
EMC AND APPLIED MATHEMATICS	UE	5 credits
Aeronautic EMC 1	Matière	
Electromagnetic compatibility	Matière	
High Performance Computing	Matière	
Variational methods for solving partial differential equations of physics	Matière	
Multiphysics Models	Matière	
NUMERICAL METHODS AND OPTIMISATION	UE	5 credits
Topological Optimisation	Matière	
Finite element numerical modelling	Matière	
Optimal control	Matière	
Finished volumes	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits

Professional Communication and English-Semestre 9	Bloc	
Scientific English	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX Careers and Management 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and Social Responsibility	Matière	
Semestre 9 - Control Architecture Computer Science and Embedded Systems (ACISE)	Choix	30 credits
SYSTEMS CONTROL, FILTERING AND DIAGNOSTIC	UE	5 credits
Filtering estimation	Matière	
System Monitoring and Diagnostics	Matière	
Multidimensional Systems	Matière	
SYSTEMS OPTIMISATION AND THEIR CONTROL	UE	5 credits
Robust control	Matière	
Optimal Control	Matière	
Combinatorial optimization	Matière	
Opti TER	Matière	
Linear programming and unimodularity	Matière	
Continuous optimization	Matière	
MODELING, ANALYSIS, SIMULATION OF DISCRETE SYSTEMS	UE	5 credits
Modeling and analysis of discrete systems	Matière	
Simulation of discrete event systems	Matière	
Planning and Scheduling	Matière	
Hybrid Dynamic Systems	Matière	
Flexible Workshop TER	Matière	
ADVANCED CONTROLLED SYSTEMS	UE	5 credits
Adaptive and predictive controls	Matière	
Aeronautical systems	Matière	
Robotics: Modeling and Control	Matière	
Advanced Control TER	Matière	
Electrical Systems Control	Matière	
ADVANCED CRITICAL COMPUTING SYSTEMS	UE	5 credits
IT Security	Matière	
IT operational security	Matière	
Safety Testing and Evaluation	Matière	
Development of critical computer systems	Module	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1 -Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	

CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Advanced Electromechanics (EMA)	Choix	30 credits
PHYSICS FOR MECHATRONICS	UE	5 credits
Advanced phenomena in electromechanical conversion	Matière	
Introduction to Magnetohydrodynamics	Matière	
Modeling of coupled phenomena	Matière	
NUMERICAL METHODS AND OPTIMISATION	UE	5 credits
Finite element numerical modelling	Matière	
Optimal control	Matière	
Optimised sizing of electrical machines	Matière	
Numerical modelling of machines	Matière	
DESIGN OF ELECTROMECHANICAL SYSTEMS	UE	5 credits
Design elements of static converters	Matière	
Mechanical design of actuators and generators	Matière	
Introduction to CAD	Matière	
Electric Generators	Matière	
ARCHITECTURES OF MECHATRONIC SYSTEMS	UE	5 credits
Multidimensional Systems	Matière	
Electric actuator control strategy	Matière	
TER Electric Actuator Control	Matière	
Electromagnetic compatibility	Matière	
Filtering estimation	Matière	
APPLIED MECHATRONICS	UE	5 credits
TER Advanced Control (EMA)	Matière	
Elastic metamaterials and actuators for space (Universeh)	Matière	
Winding techniques for electrical machines	Matière	
System Monitoring and Diagnostics	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1 -Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Energy conversion and electrical networks (CERE)	Choix	30 credits
POWER SYSTEMS AND NETWORKS	UE	5 credits
System design	Matière	

Static Converters for power network conditioning	Matière	
Static Converters HVDC Networks	Matière	
CVS DESIGN	UE	5 credits
CVS Design	Matière	
CVS control	Matière	
Architecture and Control TER	Matière	
Power Electronic Technology	Matière	
STATIC CONVERTER AND ADVANCED SYSTEMS	UE	5 credits
CVS reliability	Matière	
EMC	Matière	
X. Levels	Matière	
Switching and functional integration	Matière	
ACTUATORS AND GENERATORS	UE	5 credits
Actuator control	Matière	
Actuator Control TER	Matière	
Multidimensional Systems	Matière	
SMARTGRIDS AND MICROGRIDS	UE	5 credits
Autonomous networks	Matière	
Sources, reversibility, storage	Matière	
Smart grids	Matière	
1/2 Themed days	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1-Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Artificial Intelligence and Information Processing (IATI)	Choix	30 credits
SIGNAL AND APPLICATIONS	UE	5 credits
Antenna processing	Matière	
Automatic speech processing	Matière	
Audio et musique	Matière	
Satellite navigation	Matière	
AI AND HARDWARE	UE	5 credits
Edge computing	Matière	
Design of NN dedicated to embedded systems	Matière	
ELECTIVE TEACHING UNIT	Bloc	15 credits
ELECTIVE TEACHING UNIT SIA	Choix	
IMAGE - APPLICATIONS	UE	5 credits
Computational imaging	Matière	
Computational medical imaging	Matière	

Teledetection	Matière	
LEARNING AND DECISION	UE	5 credits
Data analysis	Matière	
Unsupervised learning	Matière	
Supervised learning	Matière	
VISION, AUGMENTED REALITY AND APPLICATIONS	UE	5 credits
Computer vision and augmented reality	Matière	
Transversal project	Matière	
ELECTIVE TEACHING UNIT TSE	Choix	
EMBEDDED SYSTEMS	UE	5 credits
System on Chip	Matière	
Architecture and hardware acceleration for DL	Matière	
AI AND SENSORS	UE	5 credits
Intelligent instrumentation chain technology	Matière	
Smart Sensor Project	Matière	
ADVANCED AI	UE	5 credits
Loosely supervised learning, RNN	Matière	
Data analysis 2 and classification	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1-Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - EcoEnergy (EE)	Choix	30 credits
SYSTEMIC DESIGN	UE	5 credits
System modeling in Bond Graph	Matière	
Eco-design and LCA	Matière	
Hydrogen supply chain	Matière	
Optimization of energy processes and systems	Matière	
SMART-GRIDS	UE	5 credits
Decentralized, embedded electrical networks	Matière	
Energy Hybridization of Systems	Matière	
Smart grids	Matière	
HYDROGEN VECTOR	UE	5 credits
Hydrogen production	Matière	
Hydrogen storage	Matière	
Fuel cells and hydrogen applications	Matière	
Electrochemistry	Matière	
RENEWABLE ENERGIES	UE	5 credits
Wind Power Systems	Matière	

Photovoltaic APP	Matière	
Low-Power Hydroelectric Installations	Matière	
NON ELECTRIC RENEWABLE ENERGIES	Élément	5 credits
	constitutif	
Biofuel systems	Matière	
Valorisation Biomasse Haute Température	Matière	
Renewable heat	Matière	
GENERAL TRAINING	UE	5 credits
Professional English-LV1 -Semestre 3	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
Themed Day: Energy and Sustainable Development	Matière	
Semestre 9 - Impact Entrepreneurship Low to Deep Tech 3EA	Choix	30 credits
Choix UE Hard Skills 3EA Parcours Impact Entrepreneurship	Bloc	
Choix UE Parc. InSys Parc. Impact Entrepreneurship	Choix	
ADVANCED DIGITAL ELECTRONICS	UE	5 credits
FPGA system design for signal processing	Matière	
Circuit testing and fault simulation	Matière	
POWER MANAGEMENT	UE	5 credits
Microprocessor Power Supply	Matière	
MOSFET Driver Circuits	Matière	
EMC for SMPS	Matière	
FEM Modeling of Integrated passive filters	Matière	
ADVANCED RADIOFREQUENCY ELECTRONICS	UE	5 credits
RF equipment	Matière	
MMIC	Matière	
MEMS	Matière	
ANALOG ELECTRONIC SYSTEMS IN RADIOFREQUENCIES	UE	5 credits
Optoelectronic Components and Circuits	Matière	
Filter Synthesis	Matière	
Integrated photonics	Matière	
Internet of Things	Matière	
DIGITAL SYSTEMS	UE	5 credits
Synthesis strategy	Matière	
EMC for integrated circuits	Matière	
System on Chip	Matière	
ANALOG AND DIGITAL SYSTEMS	UE	5 credits
ADC and DAC	Matière	
Space Embedded Systems Conferences	Matière	
Integration of instrumentation chains	Matière	
Reliability of embedded systems	Matière	
APPROFONDISSEMENT ANALOGIQUE	UE	5 credits
Introduction to Cadence Layout XL / Spectrum	Matière	
Analog ASIC project	Matière	

Choix UE Parc. SysCom Parc. Impact Entrepreneurship	Choix	
ADVANCED RADIOFREQUENCY ELECTRONICS	UE	5 credits
RF equipment	Matière	
MMIC	Matière	
MEMS	Matière	
PROPAGATION PHENOMENA AND RADAR	UE	5 credits
Actual propagation of electromagnetic waves	Matière	
Electromagnetic diffraction analysis / Radar equipment	Matière	
Radar project	Matière	
APPLIED PHYSICS AND NUMERICAL METHODS	UE	5 credits
Electromagnetism and multiscale devices	Matière	
Multiphysics Models	Matière	
Electromagnetism and nanoelectronics	Matière	
Synthesis of High Frequency Equivalent Electrical Circuits	Matière	
HIGH FREQUENCY EMBEDDED SYSTEMS	UE	5 credits
Microwave and Optical Sensors	Matière	
HF optoelectronic components and circuits	Matière	
Internet of Things	Matière	
Passive high frequency devices in waveguide technology	Matière	
MICROWAVE CIRCUITS AND ELECTROMAGNETIC COMPATIBILITY	UE	5 credits
Antenna networks	Matière	
Space antennas	Matière	
Aeronautical EMC 1	Matière	
Space Embedded Systems Conferences	Matière	
Microwave power amplifiers	Matière	
Aeronautical EMC 2	Matière	
MODELING	UE	5 credits
Variational methods for solving partial differential equations of physics	Matière	
Integral methods	Matière	
Plasma physics and applications	Matière	
Choix UE Parc. ACISE Parcours Impact Entrepreneurship	Choix	
SYSTEMS CONTROL, FILTERING AND DIAGNOSTIC	UE	5 credits
Filtering estimation	Matière	
System Monitoring and Diagnostics	Matière	
Multidimensional Systems	Matière	
SYSTEMS OPTIMISATION AND THEIR CONTROL	UE	5 credits
Robust control	Matière	
Optimal Control	Matière	
Combinatorial optimization	Matière	
Opti TER	Matière	
Linear programming and unimodularity	Matière	
Continuous optimization	Matière	
MODELING, ANALYSIS, SIMULATION OF DISCRETE SYSTEMS	UE	5 credits
Modeling and analysis of discrete systems	Matière	
Simulation of discrete event systems	Matière	
Planning and Scheduling	Matière	

Hybrid Dynamic Systems	Matière	
Flexible Workshop TER	Matière	
ADVANCED CONTROLLED SYSTEMS	UE	5 credits
Adaptive and predictive controls	Matière	
Aeronautical systems	Matière	
Robotics: Modeling and Control	Matière	
Advanced Control TER	Matière	
Electrical Systems Control	Matière	
ADVANCED CRITICAL COMPUTING SYSTEMS	UE	5 credits
IT Security	Matière	
IT operational security	Matière	
Safety Testing and Evaluation	Matière	
Development of critical computer systems	Module	
Choix UE Parc.CERE Parcours Impact Entrepreneurship	Choix	
POWER SYSTEMS AND NETWORKS	UE	5 credits
System design	Matière	
Static Converters for power network conditioning	Matière	
Static Converters HVDC Networks	Matière	
CVS DESIGN	UE	5 credits
CVS Design	Matière	
CVS control	Matière	
Architecture and Control TER	Matière	
Power Electronic Technology	Matière	
STATIC CONVERTER AND ADVANCED SYSTEMS	UE	5 credits
CVS reliability	Matière	
EMC	Matière	
X. Levels	Matière	
Switching and functional integration	Matière	
ACTUATORS AND GENERATORS	UE	5 credits
Actuator control	Matière	
Actuator Control TER	Matière	
Multidimensional Systems	Matière	
SMARTGRIDS AND MICROGRIDS	UE	5 credits
Autonomous networks	Matière	
Sources, reversibility, storage	Matière	
Smart grids	Matière	
1/2 Themed days	Matière	
Choix UE Parc. EMA Parcours Impact Entrepreneurship	Choix	
PHYSICS FOR MECHATRONICS	UE	5 credits
Advanced phenomena in electromechanical conversion	Matière	
Introduction to Magnetohydrodynamics	Matière	
Modeling of coupled phenomena	Matière	
NUMERICAL METHODS AND OPTIMISATION	UE	5 credits
Finite element numerical modelling	Matière	
Optimal control	Matière	
Optimised sizing of electrical machines	Matière	

Numerical modelling of machines	Matière	
DESIGN OF ELECTROMECHANICAL SYSTEMS	UE	5 credits
Design elements of static converters	Matière	
Mechanical design of actuators and generators	Matière	
Introduction to CAD	Matière	
Electric Generators	Matière	
ARCHITECTURES OF MECHATRONIC SYSTEMS	UE	5 credits
Multidimensional Systems	Matière	
Electric actuator control strategy	Matière	
TER Electric Actuator Control	Matière	
Electromagnetic compatibility	Matière	
Filtering estimation	Matière	
APPLIED MECHATRONICS	UE	5 credits
TER Advanced Control (EMA)	Matière	
Elastic metamaterials and actuators for space (Universeh)	Matière	
Winding techniques for electrical machines	Matière	
System Monitoring and Diagnostics	Matière	
Choix UE Parc. PN Parcours Impact Entrepreneurship	Choix	
METHODES NUMERIQUES ET OPTIMISATION-2	UE	5 credits
Optimal control	Matière	
High Performance Computing	Matière	
Simulation Numérique en optique	UE	
Topological Optimisation	Matière	
Finished volumes	Matière	
METHODES NUMERIQUES POUR LES PROBLEMES DE DIFFRACTION	UE	5 credits
Integral methods	Matière	
Electromagnetic diffraction analysis / Radar equipment	Matière	
Integral methods	Matière	
CEM ET MATHEMATIQUES APPLIQUEES	UE	5 credits
Multiphysics Models	Matière	
Variational methods for solving partial differential equations of physics	Matière	
Aeronautical EMC 1	Matière	
Electromagnetic compatibility	Matière	
High Performance Computing	Matière	
PHYSIQUE POUR LA MECATRONIQUE - PN	UE	5 credits
Plasma physics and applications	Matière	
Advanced phenomena in electromechanical conversion	Matière	
Modeling of coupled phenomena	Matière	
Introduction to Magnetohydrodynamics	Matière	
HIGH PERFORMANCE COMPUTING	UE	5 credits
Advanced Languages for programming	Matière	
Advanced Techniques for Scientific computing	Matière	
Meshing, Pre and Post Processing	Matière	
Choix UE Parc. EE Parcours Impact Entrepreneurship	Choix	
SYSTEMIC DESIGN	UE	5 credits
System modeling in Bond Graph	Matière	

Eco-design and LCA	Matière	
Hydrogen supply chain	Matière	
Optimization of energy processes and systems	Matière	
SMART-GRIDS	UE	5 credits
Decentralized, embedded electrical networks	Matière	
Energy Hybridization of Systems	Matière	
Smart grids	Matière	
RENEWABLE ENERGIES	UE	5 credits
Wind Power Systems	Matière	
Photovoltaic APP	Matière	
Low-Power Hydroelectric Installations	Matière	
GENERAL TRAINING	UE	5 credits
Professional English-LV1-Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
Themed Day: Energy and Sustainable Development	Matière	
Choix UE Parc. IATI Parcours Impact Entrepreneurship	Choix	
SIGNAL AND APPLICATIONS	UE	5 credits
Antenna processing	Matière	
Automatic speech processing	Matière	
Audio et musique	Matière	
Satellite navigation	Matière	
AI AND HARDWARE	UE	5 credits
Edge computing	Matière	
Design of NN dedicated to embedded systems	Matière	
IMAGE - APPLICATIONS	UE	5 credits
Computational imaging	Matière	
Computational medical imaging	Matière	
Teledetection	Matière	
LEARNING AND DECISION	UE	5 credits
Data analysis	Matière	
Unsupervised learning	Matière	
Supervised learning	Matière	
EMBEDDED SYSTEMS	UE	5 credits
System on Chip	Matière	
Architecture and hardware acceleration for DL	Matière	
AI AND SENSORS	UE	5 credits
Intelligent instrumentation chain technology	Matière	
Smart Sensor Project	Matière	
ADVANCED AI	UE	5 credits
Loosely supervised learning, RNN	Matière	
Data analysis 2 and classification	Matière	
VISION, AUGMENTED REALITY AND APPLICATIONS	UE	5 credits
Computer vision and augmented reality	Matière	

Transversal project	Matière	
SOFT SKILLS 1 - PARTNERSHIPS	UE	5 credits
UT ou TBS ou TSM 1 - module 18h	Matière	
UT ou TBS ou TSM 2 - module 18h	Matière	
UT ou TBS ou TSM 3 - module 18h	Matière	
SOFT SKILLS 2 - DESIGN THINKING	UE	5 credits
Design Thinking 1 - module 15h	Matière	
Design Thinking 2 - module 18h	Matière	
Professional Communication and English - module 21h	Matière	
SOFT SKILLS 3 - PROJET DEEP TECH & APPLICATIONS	UE	5 credits
PDT & CU 1 - module 18h	Matière	
PDT & CU 2 - module 18h	Matière	
PDT & CU 3 - module 18h	Matière	

Semestre 10 3EA à N7

	Nature	CM	TD	TP	Crédits
Projet Fin d'Etude 3EA sans Projet Long	UE				30 credits
Stage 2A 3EA	Matière				6 credits
PFE 3EA sans PL	Stage				24 credits
PFE 3EA avec Projet Long	UE				30 credits
Stage 2A 3EA	Matière				6 credits
Projet Long 3EA	UE				8 credits
Projet de Fin d'Etudes 3EA	UE				22 credits

Ingénieur ENSEEIHT Electronique et Génie Electrique (Apprentis)

Ingénieur ENSEEIHT Electronique et Génie Electrique



ECTS
180 credits



Duration
3 ans



Teaching
organization
Formation en
alternance,
Formation
initiale

Program

Ingénieur ENSEEIHT par l'Apprentissage Electronique et Génie Electrique (En-Ge) 1ère année

Semestre 5-1A En-Ge FISA

	Nature	CM	TD	TP	Crédits
MATHEMATICS AND COMPUTER SCIENCE FOR ENGINEER	UE				4 credits
Math Review	UE				
Computer Science for Engineers	UE				
MATHEMATICS AND SCIENTIFIC COMPUTING	UE				4 credits
Real and Complex Analysis	UE				
Matlab-Simulink	UE				
APPLIED ELECTRICITY	UE				4 credits
Circuit basics	UE				
Single-phase systems	UE				
Single-phase transformer	UE				
ELECTRONIC COMPONENTS AND CIRCUITS	UE				4 credits
Electronic Components	UE				
Circuit theory	UE				
Basic Electronic Function Project	UE				
Analog circuits	UE				
SCIENCES HUMAINES SOCIALES ET JURIDIQUES-S5-FISA	UE				4 credits
Careers and Management 1	Matière				
Careers and Management 2	Matière				
Anglais Professionnel-S5-App	Matière				
COMPANY SEMESTER 5	UE				10 credits

Semestre 6-1A En-Ge FISA

	Nature	CM	TD	TP	Crédits
MATHEMATICS AND COMPUTER SCIENCE FOR ENGINEERS	UE				4 credits
Real analysis	UE				
Probabilities and Statistics	UE				
Calculator Structure	UE				
ANALOG ELECTRONICS	UE				4 credits
Analog Electronics Project	UE				
Electronic Functions	UE				
Analog circuits	UE				

LINEAR CIRCUITS AND SYSTEMS	UE	4 credits
Combinatorial and sequential logic	UE	
Filtering	UE	
Continuous Linear Systems	UE	
ELECTRICAL NETWORKS AND ENERGY CONVERSION	UE	4 credits
Introduction to Static Conversion	UE	
Switching power supply - Non-isolated structures	UE	
Introduction to Electromechanical Conversion	UE	
Three-phase networks	UE	
SCIENCES HUMAINES SOCIALES ET JURIDIQUES-S6-FISA	UE	4 credits
Anglais Professionnel-S6-FISA	Matière	
Careers and Management 1	Matière	
Careers and Management 2	Matière	
COMPANY SEMESTER 6	UE	10 credits

Ingénieur ENSEIHT Electronique et GE 2ème année (Apprentis)

Semestre 7-2A-En-Ge FISA

	Nature	CM	TD	TP	Crédits
MATHEMATICS AND COMPUTER SYSTEMS	UE				4 credits
Partial Differential Equation	UE				
Modeling and Development of Industrial Systems: Programmed Logic	UE				
Modeling and Development of Industrial Systems—Object-Oriented Modeling and Development	UE				
DIGITAL SYSTEMS AND DIGITAL SIGNAL PROCESSING	UE				4 credits
Microprocessors	UE				
Digital Signal Processing	UE				
STATIC CONVERSION AND THEIR CONTROL	UE				4 credits
Design and implementation of Static Converters	UE				
Closed-loop control of continuous linear systems	UE				
ELECTIVE TEACHING UNIT	UE				4 credits
OPTION EN: MATERIAL DESCRIPTION LANGUAGES and TR	UE				4 credits
Digital design in VHDL	UE				
VHDL Project	UE				
DSP, Digital Filtering	Élément constitutif				
OPTION ENERGY: ELECTROMECHANIC CONVERSION	Matière				4 credits
Machine Modeling	UE				
Principles and structures of electrical machines	LV2 facultative				
SCIENCES HUMAINES SOCIALES ET JURIDIQUES-S7-FISA	UE				4 credits

Anglais Professionnel-S7-App
 Careers and Management 1- App Sem7
 Careers and Management 2- APP Sem7

Matière
 Matière
 Matière

COMPANY SEMESTER 7

UE

10 credits

Semestre 8-2A-En-Ge FISA

	Nature	CM	TD	TP	Crédits
ELECTIVE OPTIONS	UE				16 credits
ENERGY OPTION	UE				16 credits
ELECTRIC SYSTEM	Choix				4 credits
Machine/converter association and their control	UE				
Analysis and modeling of a vehicle through reverse engineering	Stage				
AUTOMATIC AND TR	UE				4 credits
Space State	UE				
sampled linear systems	UE				
Real Time Informatics	UE				
Non Linear Systems	UE				
ECO-ENERGY	UE				4 credits
FACTS Introduction	UE				
Renewable Energies	UE				
POWER ELECTRONICS	UE				4 credits
Inverter	UE				
Switching Mechanisms	UE				
Thermics	UE				
ELECTRONIC OPTION	UE				16 credits
ANALOG CIRCUIT DESIGN	Choix				4 credits
Linear Circuits	UE				
Non Linear Circuits	UE				
Analog Electronics Project	UE				
PROPAGATION AND RADIATION	LV2				4 credits
	facultative				
Transmission Lines	UE				
Electromagnetism and guided propagation	UE				
Radiation and Antennas	UE				
OPTOELECTRONICS AND RADIOFREQUENCIES	UE				4 credits
Optoelectronics	UE				
RF Circuit	UE				
MMIC	UE				
RF-Digital Project	UE				
INTEGRATION	UE				4 credits
MOS	UE				
Front-End instrumentation	UE				
Design and FPGA	UE				
SCIENCES HUMAINES SOCIALES ET JURIDIQUES-S8-FISA	UE				4 credits

Anglais Professionnel-S8-App	Matière	
Careers and Management 1	Matière	
Careers and Management 2	Matière	
COMPANY SEMESTER 8	UE	10 credits

Ingenieur ENSEIHT Electronique et GE 3ème année (Apprentis)

	Nature	CM	TD	TP	Crédits
Semestre 9 FISA (manuel)					
	Nature	CM	TD	TP	Crédits
Semestre 9 - Systems Integration (INSYS)	Choix				30 credits
ANALOG ELECTRONIC SYSTEMS IN RADIOFREQUENCIES	UE				5 credits
Optoelectronic Components and Circuits	Matière				
Filter Synthesis	Matière				
Integrated photonics	Matière				
Internet of Things	Matière				
DIGITAL SYSTEMS	UE				5 credits
Synthesis strategy	Matière				
EMC for integrated circuits	Matière				
System on Chip	Matière				
ANALOG AND DIGITAL SYSTEMS	UE				5 credits
ADC and DAC	Matière				
Space Embedded Systems Conferences	Matière				
Integration of instrumentation chains	Matière				
Reliability of embedded systems	Matière				
1st ELECTIVE TEACHING UNIT	UE				5 credits
ADVANCED DIGITAL ELECTRONICS	UE				5 credits
FPGA system design for signal processing	Matière				
Circuit testing and fault simulation	Matière				
ADVANCED ANALOG ELECTRONICS	UE				5 credits
Introduction to Cadence Layout XL / Spectrum	Matière				
Analog ASIC project	Matière				
2nd ELECTIVE TEACHING UNIT	UE				5 credits
POWER MANAGEMENT	UE				5 credits
Microprocessor Power Supply	Matière				
MOSFET Driver Circuits	Matière				
EMC for SMPS	Matière				
FEM Modeling of Integrated passive filters	Matière				
ADVANCED RADIOFREQUENCY ELECTRONICS	UE				5 credits
RF equipment	Matière				
MMIC	Matière				
MEMS	Matière				
SOFT AND HUMAN SKILLS 3EA S9	UE				5 credits
Professional English-LV1-Semestre 9	Bloc				

Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Communication Systems (SYSCOM)	Choix	30 credits
APPLIED PHYSICS AND NUMERICAL METHODS	UE	5 credits
Electromagnetism and multiscale devices	Matière	
Multiphysics Models	Matière	
Electromagnetism and nanoelectronics	Matière	
Synthesis of High Frequency Equivalent Electrical Circuits	Matière	
HIGH FREQUENCY EMBEDDED SYSTEMS	UE	5 credits
Microwave and Optical Sensors	Matière	
HF optoelectronic components and circuits	Matière	
Internet of Things	Matière	
Passive high frequency devices in waveguide technology	Matière	
MICROWAVE CIRCUITS AND ELECTROMAGNETIC COMPATIBILITY	UE	5 credits
Antenna networks	Matière	
Space antennas	Matière	
Aeronautical EMC 1	Matière	
Space Embedded Systems Conferences	Matière	
Microwave power amplifiers	Matière	
Aeronautical EMC 2	Matière	
PROPAGATION PHENOMENA AND RADAR	UE	5 credits
Actual propagation of electromagnetic waves	Matière	
Electromagnetic diffraction analysis / Radar equipment	Matière	
Radar project	Matière	
ELECTIVE TEACHING UNIT	Choix	5 credits
ADVANCED RADIOFREQUENCY ELECTRONICS	UE	5 credits
RF equipment	Matière	
MMIC	Matière	
MEMS	Matière	
MODELING	UE	5 credits
Variational methods for solving partial differential equations of physics	Matière	
Integral methods	Matière	
Plasma physics and applications	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1 -Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	

CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Control Architecture Computer Science and Embedded Systems (ACISE)	Choix	30 credits
SYSTEMS CONTROL, FILTERING AND DIAGNOSTIC	UE	5 credits
Filtering estimation	Matière	
System Monitoring and Diagnostics	Matière	
Multidimensional Systems	Matière	
SYSTEMS OPTIMISATION AND THEIR CONTROL	UE	5 credits
Robust control	Matière	
Optimal Control	Matière	
Combinatorial optimization	Matière	
Opti TER	Matière	
Linear programming and unimodularity	Matière	
Continuous optimization	Matière	
MODELING, ANALYSIS, SIMULATION OF DISCRETE SYSTEMS	UE	5 credits
Modeling and analysis of discrete systems	Matière	
Simulation of discrete event systems	Matière	
Planning and Scheduling	Matière	
Hybrid Dynamic Systems	Matière	
Flexible Workshop TER	Matière	
ADVANCED CONTROLLED SYSTEMS	UE	5 credits
Adaptive and predictive controls	Matière	
Aeronautical systems	Matière	
Robotics: Modeling and Control	Matière	
Advanced Control TER	Matière	
Electrical Systems Control	Matière	
ADVANCED CRITICAL COMPUTING SYSTEMS	UE	5 credits
IT Security	Matière	
IT operational security	Matière	
Safety Testing and Evaluation	Matière	
Development of critical computer systems	Module	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1 -Semestre 3	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	

Semestre 9 - Advanced Electromechanics (EMA)	Choix	30 credits
PHYSICS FOR MECHATRONICS	UE	5 credits
Advanced phenomena in electromechanical conversion	Matière	
Introduction to Magnetohydrodynamics	Matière	
Modeling of coupled phenomena	Matière	
NUMERICAL METHODS AND OPTIMISATION	UE	5 credits
Finite element numerical modelling	Matière	
Optimal control	Matière	
Optimised sizing of electrical machines	Matière	
Numerical modelling of machines	Matière	
DESIGN OF ELECTROMECHANICAL SYSTEMS	UE	5 credits
Design elements of static converters	Matière	
Mechanical design of actuators and generators	Matière	
Introduction to CAD	Matière	
Electric Generators	Matière	
ARCHITECTURES OF MECHATRONIC SYSTEMS	UE	5 credits
Multidimensional Systems	Matière	
Electric actuator control strategy	Matière	
TER Electric Actuator Control	Matière	
Electromagnetic compatibility	Matière	
Filtering estimation	Matière	
APPLIED MECHATRONICS	UE	5 credits
TER Advanced Control (EMA)	Matière	
Elastic metamaterials and actuators for space (Universeh)	Matière	
Winding techniques for electrical machines	Matière	
System Monitoring and Diagnostics	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1-Semestre 3	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - Energy conversion and electrical networks (CERE)	Choix	30 credits
POWER SYSTEMS AND NETWORKS	UE	5 credits
System design	Matière	
Static Converters for power network conditioning	Matière	
Static Converters HVDC Networks	Matière	
CVS DESIGN	UE	5 credits
CVS Design	Matière	
CVS control	Matière	

Architecture and Control TER	Matière	
Power Electronic Technology	Matière	
STATIC CONVERTER AND ADVANCED SYSTEMS	UE	5 credits
CVS reliability	Matière	
EMC	Matière	
X. Levels	Matière	
Switching and functional integration	Matière	
ACTUATORS AND GENERATORS	UE	5 credits
Actuator control	Matière	
Actuator Control TER	Matière	
Multidimensional Systems	Matière	
SMARTGRIDS AND MICROGRIDS	UE	5 credits
Autonomous networks	Matière	
Sources, reversibility, storage	Matière	
Smart grids	Matière	
1/2 Themed days	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1 -Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	
Corporate Project and social responsibility	Matière	
Semestre 9 - EcoEnergy (EE)	Choix	30 credits
SYSTEMIC DESIGN	UE	5 credits
System modeling in Bond Graph	Matière	
Eco-design and LCA	Matière	
Hydrogen supply chain	Matière	
Optimization of energy processes and systems	Matière	
SMART-GRIDS	UE	5 credits
Decentralized, embedded electrical networks	Matière	
Energy Hybridization of Systems	Matière	
Smart grids	Matière	
HYDROGEN VECTOR	UE	5 credits
Hydrogen production	Matière	
Hydrogen storage	Matière	
Fuel cells and hydrogen applications	Matière	
Electrochemistry	Matière	
RENEWABLE ENERGIES	UE	5 credits
Wind Power Systems	Matière	
Photovoltaic APP	Matière	
Low-Power Hydroelectric Installations	Matière	

NON ELECTRIC RENEWABLE ENERGIES	Élément constitutif	5 credits
Biofuel systems	Matière	
Valorisation Biomasse Haute Température	Matière	
Renewable heat	Matière	
GENERAL TRAINING	UE	5 credits
Professional English-LV1-Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
Themed Day: Energy and Sustainable Development	Matière	
METHODES NUMERIQUES ET OPTIMISATION-2	UE	5 credits
Optimal control	Matière	
High Performance Computing	Matière	
Simulation Numérique en optique	UE	
Topological Optimisation	Matière	
Finished volumes	Matière	
METHODES NUMERIQUES POUR LES PROBLEMES DE DIFFRACTION	UE	5 credits
Integral methods	Matière	
Electromagnetic diffraction analysis / Radar equipment	Matière	
Integral methods	Matière	
CEM ET MATHEMATIQUES APPLIQUEES	UE	5 credits
Multiphysics Models	Matière	
Variational methods for solving partial differential equations of physics	Matière	
Aeronautical EMC 1	Matière	
Electromagnetic compatibility	Matière	
High Performance Computing	Matière	
PHYSIQUE POUR LA MECATRONIQUE - PN	UE	5 credits
Plasma physics and applications	Matière	
Advanced phenomena in electromechanical conversion	Matière	
Modeling of coupled phenomena	Matière	
Introduction to Magnetohydrodynamics	Matière	
SOFT AND HUMAN SKILLS 3EA S9	UE	5 credits
Professional English-LV1-Semestre 9	Bloc	
Anglais Scientifique	Matière	
Choix 2 Anglais Professionnel - 3A	Choix	
Anglais Clinique	Matière	
Anglais de Cambridge ou Projet	Matière	
CV Entretiens(3EA)	Matière	
Recherche doc.(3EA)	Matière	
CHOIX SHS 3EA S9	Choix	
Entrepreneurship Project	Matière	

Corporate Project and social responsibility

HIGH PERFORMANCE COMPUTING

Advanced Languages for programming
 Advanced Techniques for Scientific computing
 Meshing, Pre and Post Processing

Matière

UE

5 credits

Matière

Matière

Matière

Semestre 9 Parcours Physique Numérique-3A-3EA

	Nature	CM	TD	TP	Crédits
OUTILS NUMERIQUES POUR LA PROPAGATION	UE				5 credits
PHYSIQUE ET OPTIMISATION	UE				5 credits
Physique et modélisation	Matière				
METHODES NUMERIQUES	UE				5 credits
Projet Méthode numérique et calcul haute performance	Matière				
HIGH PERFORMANCE COMPUTING	UE				5 credits
Advanced Languages for programming	Matière				
Advanced Techniques for Scientific computing	Matière				
Meshing, Pre and Post Processing	Matière				

Semestre 10 3EA à N7

	Nature	CM	TD	TP	Crédits
Projet Fin d'Etude 3EA sans Projet Long	UE				30 credits
Stage 2A 3EA	Matière				6 credits
PFE 3EA sans PL	Stage				24 credits
PFE 3EA avec Projet Long	UE				30 credits
Stage 2A 3EA	Matière				6 credits
Projet Long 3EA	UE				8 credits
Projet de Fin d'Etudes 3EA	UE				22 credits

Integration and probabilities

 **ECTS**
5 credits

 **Component**
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

 **Semester**
Automne

In brief

> **Ametys Code:** N5EE01

List of courses

	Nature	CM	TD	TP	Crédits
Integration	UE				
Complex Variable	UE				
Probabilities	UE				

Integration



Component

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d'Informatique
d'Hydraulique
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Télécommunications



Semester

Automne

In brief

➤ **Ametys Code:** N5EE01A

➤ **Open to exchange students:** Yes

Presentation

Objectives

At the end of this class, students will be able to calculate integrals and frequency representations encountered in physics (Fourier series and transformations). A second objective is the comprehension of the mathematical tools for this frequency analysis, in particular the Lebesgue integration.

Description

This course is divided into 6 classes and 5 tutorials. Following a presentation of the Lebesgue integration, the class will focus on the results enabling the calculation of integrals:

Interchanging limits and integrals continuity and differentiation of an integral, change of variables and integration in n dimensions. The frequency representations of periodic functions (Fourier series) and integrable functions (Fourier transform), will be defined focusing on the properties of these representations. Finally, the convolution operation and its connection to the Fourier transform will be studied.

Complex Variable



Component

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d'Hydraulique
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Semester

Automne

In brief

- **Amety's Code:** N5EE01B
- **Open to exchange students:** Yes

Presentation

Description

Definition, properties, direct and inverse calculation of the Laplace transform.

Definition, properties, direct and inverse calculation of the Z transform.

Standard algebra of complex numbers: properties, geometry related to vector representation. Differentiable functions of two real variables.

Curvilinear integrals

Pre-requisites

Standard algebra of complex numbers: properties, geometry related to vector representation. Differential functions of two-real variables.

Curvilinear integrals.

Probabilities



Component

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Télécommunications



Semester

Automne

In brief

➤ **Ametys Code:** N5EE01C

➤ **Open to exchange students:** Yes

Presentation

Objectives

The aim of this course is to enable the future engineer to build a mathematical model based on the observation of a random phenomenon and a collection of experimental or sampling data. This construction goes from the choice of model to its precise adjustment and its validation. This model must then allow a better understanding or analysis of the phenomenon and lead, if necessary, to decision-making or forecasts.

Description

1st course: Probability in infinite and uncountable spaces.

2nd course: Real random variables; basic concepts ; discrete distributions.

3rd course: Real random variables; probability density functions.

4th course: End of random variables; change of variable. Random vectors.

5th course: Correlation; marginal distributions; Independence. Change of variables. 6th course: Characteristic function.

Convergences. Law of large numbers. 7th course: Complements; revisions. Tutorials

TD 1: Probability derivation.

TD 2: The discrete distributions.

TD 3: The continuous distributions.

TD 4: Bivariate change of variables.

TD 5: Characteristic function; Convergences. Practical work

TP 1 and 2: Initiation to Matlab for probabilities and statistics.

TP 3 and 4: Simulation of random variables.

Introduction to Algorithmic, Programming and Computer Architecture



ECTS
5 credits



Component
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Semester
Automne

In brief

- **Ametys Code:** N5EE02
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Algorithms and Imperative Programming	UE				
Architecture and Assembler-programming	UE				

Algorithms and Imperative Programming



Component

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Semester

Automne

In brief

- **Ametys Code:** N5EE02A
- **Open to exchange students:** Yes

Presentation

Objectives

This class aims to present the key tools used to design IT applications. The various design steps are presented in an approach ranging from reading a specification to implement on a computer-based solution (here using the C-ANSI language).

Description

There are two separated parts to the Algorithms and Imperative Programming class. The first part will focus on tools dedicated to the design of computer programs totally independent of the programming language. The program refinement and their translation into algorithmic form will be learned.

The second part discusses the specificities of the C language and the methodologies for translating and algorithm in that language.

This class is associated with a tutorial which illustrates both the design and the programming part. Different examples are dealt in order to illustrate the design process, up to the final implementation of the computer code.

Architecture and Assembler-programming



Component

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d'Informatique
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Télécommunications



Semester

Automne

In brief

- **Ametys Code:** N5EE02B
- **Open to exchange students:** Yes

Presentation

Objectives

The objective of this course is to enable students to:

- master the simplified operation of a microprocessor
- understand the operating principle of an operating system.
- master machine language and assembler
- produce a simple program in assembler
- develop a simple microcomputer/system interface
- master process control by polling
- understand the general principle of interrupts (sequence breaks)

Pre-requisites

Mandatory:

- Combinational and Sequential Logic
- Sequential System Synthesis
- Basic Logic Functions (Encoders/Decoders, Multiplexers/Demultiplexers, Counters/Decounters, Registers, etc.)
- Concept of State Machines

Optional: Concepts of Algorithms and Programming Languages.

Digital Systems Design



ECTS
5 credits



Component
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Supérieure
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d'Informatique
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Télécommunications



Semester
Automne

In brief

- **Ametys Code:** N5EE03
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Theoretical Approach of combinational and sequential logic	UE				
Digital Functions and Technologies	UE				
Project : Design of sequential and combinatoria Digital units	UE				

Theoretical Approach of combinational and sequential logic



Component

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Semester

Automne

In brief

- **Ametys Code:** N5EE03A
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the various concepts related to the design of combinational and sequential logic systems

Description

- Boolean algebra
- Truth tables
- Karnaugh maps
- Binary numbering
- State machines

Pre-requisites

None

Digital Functions and Technologies



Component

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Supérieure
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Automne

In brief

➤ **Ametys Code:** N5EE03B

➤ **Open to exchange students:** Yes

Presentation

Objectives

The main objective of this course is to cover the fundamental principles and concepts of digital electronics and to present certain technological elements related to experimental implementation.

Description

The first part will be devoted to discovering the technological principles behind simple logic functions (TTL/CMOS logic, static/dynamic aspects, power consumption). After a brief review of NMOS and PMOS transistors, a detailed analysis of the principles of constructing logic functions in CMOS logic will be presented.

The second part will cover the main functions of combinational logic (encoders, decoders, multiplexers, comparators, etc.).

The third part will address the issue of information storage, with a particular focus on the different principles for implementing a "memory point." In particular, the external and internal functioning of the main flip-flops (RS, JK, D latch, D flipflop, registers) will be detailed.

The fourth part will be devoted to the study of classic sequential functions: counters and counters (synchronous and asynchronous).

The fifth part will cover the technological principles involved in storing information. The concept of BUS (data/addresses) will be introduced. The different types of memory (RAM, SRAM, DRAM, ROM, EPROM, EEPROM, etc.) will then be presented from a technological perspective.

The sixth and final part will be devoted to an introduction to programmable components. After a brief history to put the evolution of these technologies (PAL/PLD, etc.) into context, the different functional blocks that make up an FPGA will be discussed.

Pre-requisites

UE N5EE04 Circuit Fundamentals

UE N5EE03 Logic System Design

Project : Design of sequential and combinatoria Digital units



Component

École Nationale
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Télécommunications



Semester

Automne

In brief

- **Ametys Code:** N5EE03C
- **Open to exchange students:** Yes

Presentation

Objectives

The objective of this project is to develop an application implementing combinatorial and sequential logical systems.

Description

Through the design of an application enabling the management of a video projector cabinet, the student will have to complete the program and the design of the system. A step-by-step development is offered. Many functions will be achieved by mixing sequential and combinatorial systems (displays, security code, meters, ...). Simulation and testing phases are provided throughout the project to validate progress.

Fundamental Circuit Theory

 **ECTS**
5 credits

 **Component**
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

 **Semester**
Automne

In brief

- **Ametys Code:** N5EE04
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Electric Circuits Analysis Methods	UE				
Instrumentation and Power Circuits	UE				
Circuits labs	UE				

Electric Circuits Analysis Methods



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Automne

In brief

- **Ametys Code:** N5EE04A
- **Open to exchange students:** Yes

Presentation

Objectives

Understand methods for analyzing electrical circuits under any time domain and under steady-state sinusoidal conditions. Become familiar with the formalism and software used in industry.

Description

- Signals and systems: definitions, linear systems with time invariance.
- Circuit generalities: elements, energy relations, units.
- Laplace transform: properties, applications in differential equations.
- sinusoidal steady state: Bode and Nyquist plot, energy
- General theorems: various equivalents. Quadripoles.

Instrumentation and Power Circuits



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Automne

In brief

- **Ametys Code:** N5EE04B
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of this course, the student will be familiar with the official vocabulary of metrology.

The student will distinguish between the origins of systematic and aleatory origins of the measurement errors.

The student will be able to quantify the cumulated uncertainties in any measurement process by applying the methods recommended by the "Bureau International des Poids et Mesures".

Circuits labs



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Automne

In brief

- **Ametys Code:** N5EE04C
- **Open to exchange students:** Yes

Presentation

Objectives

- Know how to use measuring devices and probes.
- Know how to safely handle live electrical circuits.
- Know how to use simulation software to supplement the theoretical study of a circuit before implementation.
- Know how to take experimental readings, present them, and analyze them.

Physics for Electrical Engineering



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

- > **Ametys Code:** N5EE05
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Electromagnetism	UE				
Material Physics	UE				
Propagation in Transmission Lines	UE				

Electromagnetism



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Automne

In brief

- **Ametys Code:** N5EE05A
- **Open to exchange students:** Yes

Presentation

Objectives

- At the end of this course, the students will have assimilated the equations of standard electrodynamics and will be able to describe their physical meaning.
- They will be able to propose a method and to formulate hypotheses useful for solving common static or propagative electromagnetic problems.
- At the end of the practical courses, students will be able to formulate the conditions required to solve an electromagnetism problem by numerical methods (ie finite elements method).

Description

- Vector calculus review: scalar field, vector field, vector potential, scalar potential.
- Electric and magnetic field equations in vacuum and in media, transition conditions and boundary conditions
- Magnetic energy and coenergy in vacuum
- Introduction to propagation phenomena

Pre-requisites

- Vector operators (div, rot, grad, Laplacian, etc.)
- Cartesian and polar coordinate systems

Material Physics



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Automne

In brief

- **Ametys Code:** N5EE05B
- **Open to exchange students:** Yes

Presentation

Objectives

By the end of this course, students will:

- understand the atomic properties of matter (microscopic scale)
- have a good understanding of the interaction between electromagnetic waves and matter (physical properties)
- know how to control the propagation of electromagnetic fields in matter (propagation, radiation, dielectric and thermal losses)
- be able to make connections with other subjects: electromagnetism, antennas, passive circuits, electrical machines

Description

The course is divided into two parts: dielectric and magnetic materials. The uses of different materials will be explained. The physical properties of materials (permittivity, permeability) will be given on a microscopic and macroscopic scale. Free and bound charges, polarization and magnetization vectors will be introduced in Maxwell's equations, which are also covered in the electromagnetism course. These charges and vectors will also be transcribed into the physical properties of materials. The transition relationships will be demonstrated.

Pre-requisites

Electrostatics

Magnetostatics

Mathematical basics

Propagation in Transmission Lines



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Automne

In brief

➤ **Ametys Code:** N5EE05C

➤ **Open to exchange students:** Yes

Presentation

Objectives

By the end of this course, students will be able to:

- understand the intrinsic parameters of a line
- understand the specifications on a datasheet
- understand the phenomenon of reflection
- understand the principles of adaptation
- know how to measure line performance
- know how to diagnose faults in lines
- understand the phenomena of coupling and crosstalk

Description

In the first course, based on the physical phenomena studied in the electromagnetism course, an RLCG circuit model (telegrapher's equation) is explained. The concepts of characteristic impedance, propagation constant, wavelength, and attenuation constant are derived from this. Group velocity, phase velocity, and line power handling are introduced.

In the second class, the line is represented as a quadrupole. The phenomena of reflection and adaptation are explained on a loaded line. The phenomenon of standing waves is illustrated.

In a final lesson, the diffraction matrix is explained. The network analyzer used to characterize it is presented. Reflectometry techniques are detailed. Cable insulation and crosstalk are presented.

Pre-requisites

Materials

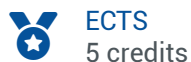
Electromagnetism: propagation phenomena

Basic concepts of circuits (four-pole networks, node and mesh laws, etc.)

Solving partial differential equations

Complex calculations

Soft and Human Skills



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

> **Ametys Code:** N5EK01

List of courses

	Nature	CM	TD	TP	Crédits
Anglais	Matière				
Second language	Choix				
Spanish	Matière				
Portuguese	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
French as a Foreign Language	Matière				
LSF - S5	Matière				
Sports	Matière				
Leadership and management	Matière				

Anglais



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **plugin.odf-inp:PLUGINS_ODF_COURSE_NBHOURS_TXT:** 21
- **Ametys Code:** N5EK01A

Presentation

Objectives

Perform key oral and written workplace tasks in English.

Description

A semester of 12 weekly sessions to develop English intercultural communication competencies for professional purposes.

Pre-requisites

Aucun.

Second language



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N5EK01B
- **Open to exchange students:** No

Presentation

Description

Develop professional communication skills by performing common written and oral communication tasks in foreign languages other than English.

List of courses

	Nature	CM	TD	TP	Crédits
Spanish	Matière				
Portuguese	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
French as a Foreign Language	Matière				
LSF - S5	Matière				

Spanish



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N5EK01BA

Portuguese



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N5EK01BB

Chinese



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N5EK01BC

Italian



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N5EK01BD

Japanese



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N5EK01BE

Russian



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N5EK01BF

German



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N5EK01BG

French as a Foreign Language



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

> **Ametys Code:** N5EK01BH

LSF - S5



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M4R9T6NG

Sports



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N5EK01C
- **Open to exchange students:** No

Presentation

Objectives

- Health seen as a set of resources that need to be mobilized and developed.
- Self-knowledge through effort.
- Access to an area of culture.

Description

- Choose a sport from a list of twenty or so (activities to suit all tastes).
- A weekly sports slot.
- Training and Cross at the end of semester 1.

Leadership and management



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **plugin.odf-inp:PLUGINS_ODF_COURSE_NBHOURS_TXT:** 21
- **Ametys Code:** N5EK01D

Presentation

Objectives

Develop key professional competencies to communicate effectively, manage projects and work in international teams.

Description

1 semester of 12 weekly sessions aimed to develop your personal professional project.

Pre-requisites

None.

Numerical Analysis and Statistics

 **ECTS**
5 credits

 **Component**
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

 **Semester**
Printemps

In brief

- **Ametys Code:** N6EE01
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Differential Calculation and Optimisation	UE				
Solving PDEs using finite differences	LV2 facultative				
Statistics	UE				

Differential Calculation and Optimisation



Component

École Nationale
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d'Électronique
d'Informatique
d'Hydraulique
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Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6EE01A
- **Open to exchange students:** Yes

Presentation

Description

This course will present Taylor's various developments for applications between two finite-dimensional vector spaces. In particular, the concepts of Hessian matrix, Jacobian matrix, and gradient vector will be introduced.

A taxonomy of optimization problems will be presented, enabling students to situate their problem in relation to the theoretical and numerical tools available for solving problems. Next, the various relationships that verify the extrema of a differentiable function (zero gradient, inertia of the Hessian matrix in the unconstrained case) will be presented, with an emphasis on the rigorous application of the necessary and sufficient conditions available. The emphasis is therefore on understanding the structure of the problem and the precise use of mathematical conditions. The following outline has been proposed:

- Introduction: classification of problems, convexity
- Existence, uniqueness, local/global minimum, necessary and sufficient conditions of order 1 and 2.
- Optimization algorithms based on Newton/Gauss-Newton/Conjugate Gradient

Solving PDEs using finite differences



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
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et des
Télécommunications

In brief

- **Ametys Code:** ELP4
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of this course, students will have learned the basics of solving partial differential equations using the finite difference method.

Description

In this course, students will study: - Elliptic Equations Discretization and solving of the equation in 1D. Study of consistency, stability, and convergence in 1D. - Parabolic Equations Discretization and solving, stability, consistency, and convergence. Explicit, implicit, Richardson, and Crank-Nicolson schemes. - Introduction to Hyperbolic Equations Presentation of a discretization and some of its properties. Examples will be drawn from the EEEA department (PN junction, electromagnetism, etc.).

Statistics



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6EE01C
- **Open to exchange students:** Yes

Presentation

Objectives

The aim of this course is to enable the future engineer to build a mathematical model based on the observation of a random phenomenon and a collection of experimental or sampling data. This construction goes from the choice of model to its precise adjustment and its validation. This model must then allow a better understanding or analysis of the phenomenon and lead, if necessary, to decision-making or forecasts.

Description

1st course: Normal distributions; mean and variance.

2nd course: Basis of estimation; unbiased estimation of minimum variance.

3rd course: Fisher Information; Cramer-Rao inequality; maximum likelihood.

4th course: Basis of hypothesis testing; Lemma of Neyman and Pearson.

5th course: Likelihood ratio test; Linear regression. 6th course: Multilinear regression.

7th course: Complements; revisions. Tutorials

TD 1: Mean-variance independence, Gaussian case.

TD 2: Estimate (1).

TD 3: Estimation (2).

TD 4: Hypothesis testing.

Signal and Control



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Printemps

In brief

- **Ametys Code:** N6EE02
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Signal Processing	UE				
Digital Signal Processing	UE				
Continuous Linear Systems Control	UE				

Signal Processing



Component

École Nationale
Supérieure
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d'Électronique
d'Informatique
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Semester

Printemps

In brief

➤ **Ametys Code:** N6EE02A

➤ **Open to exchange students:** Yes

Presentation

Objectives

- Know the different classes of signals and the properties of their representations (autocorrelation function, energy or power spectral densities).
- Identify or design linear filtering operations.
- Understand the effects of ideal and real sampling,
- Know the techniques of restitution.

Description

Chapter 1: Correlation and spectra (Fourier transform, signal classes, properties).

Chapter 2: Linear filtering (Wiener-Lee relations, interference formula).

Chapter 3: Sampling (ideal sampling, actual sampling, restitution).

Chapter 4: Nonlinear filtering (quadrator, quantification).

Digital Signal Processing



Component

École Nationale
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d'Électrotechnique
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Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6EE02B
- **Open to exchange students:** Yes

Presentation

Objectives

Laying the basics for digital signal processing: introducing the discrete Fourier transform and its main properties, conducting spectral analysis and presenting the direct methods of synthesis of digital filters.

Description

Chapter 1: The Discrete Fourier Transform

Chapter 2: Estimating the Interrelation Function

Chapter 3: Estimating the Power Spectral Density

Chapter 4: Digital Filtering

Continuous Linear Systems Control



Component

École Nationale
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d'Électronique
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Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6EE02C
- **Open to exchange students:** Yes

Presentation

Objectives

Have of knowledge of the basics related to linear system control: modeling with block diagrams and transfer functions, time and frequency analysis, stability analysis

Description

Introduction to control systems

- Linear time invariant systems
- Modeling with block-diagrams and transfer functions
- Architectures of control systems

Time and frequency analysis of linear systems

- Time response related to a particular input signal
- Harmonic analysis : Bode and Nyquist plot diagrams
- Application to particular systems: 1st order, 2nd order, 3rd order

Performance of control systems

- Static and dynamic error, time response, overshoot
- Stability analysis: Routh-Hurwitz algebraic criterion, Nyquist criterion, Bode and Nyquist simplified criteria
- Stability margins (gain and phase margins)

Pre-requisites

Laplace transform, Electrical circuits, complex numbers

Electric circuits and systems



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
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Télécommunications



Semester
Printemps

In brief

- **Ametys Code:** N6EE03
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Modeling by physical analogies & analysis	UE				
Op-amps and Compensation	UE				
Course (1 choice out of 2)	UE				
Advanced Amplifier Systems	UE				
Modeling of magnetic circuits	EC				

Modeling by physical analogies & analysis



Component

École Nationale
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Semester

Printemps

In brief

- **Ametys Code:** N6EE03A
- **Open to exchange students:** Yes

Presentation

Objectives

- Skill in energy system modelling by using electrical equivalent circuit models whatever the physical domain (electrical, mechanical, hydraulic, magnetic, thermal)
- Ability to analyse the time and frequency behaviour of specific transfer functions and apply the root locus method for stability analysis.

Description

Modeling section:

- Introduction to physical analogies in energy systems: generalized energy and power variables
- Elements of physical systems: source, dissipative, or energy storage elements (in kinetic or potential form), interconnection elements (generalized mesh and node laws, transformers, and gyrators)
- Causality in physical systems
- System examples: academic cases, level control, position control

Analysis section:

Additional information on the analysis of continuous linear systems:

- Linearization of a nonlinear system
- Time analysis: influence of poles and zeros
- Stability analysis using the root locus method

Pre-requisites

Circuit fundamentals, continuous linear systems control

Op-amps and Compensation



Component

École Nationale
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d'Informatique
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et des
Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6EE03B
- **Open to exchange students:** Yes

Presentation

Objectives

- Optimize the stability of a closed-loop system based on a circuit designed with operational amplifiers.

Description

Ideal and real operational amplifier characteristics:

- main parameters of the open-loop amplifier,
- basic closed-loop circuits with negative feedback,
- properties of the gain-bandwidth product,

Stability of a closed-loop circuit:

- compensation according to gain and frequency, phase margin.
- Slew rate.

Course (1 choice out of 2)



Component

École Nationale
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Télécommunications

In brief

- **Ametys Code:** N6EE03X
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Advanced Amplifier Systems	UE				
Modeling of magnetic circuits	EC				

Advanced Amplifier Systems



Component

École Nationale
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d'Électronique
d'Informatique
d'Hydraulique
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Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6EE03C
- **Open to exchange students:** Yes

Presentation

Objectives

Analysis of the amplification function performed by bipolar transistors as a function of frequency. Study of differential amplifier circuitry.

Description

- Frequency response of capacitively coupled amplifiers: study at low and high frequencies
- Differential circuits: differential and common mode, symmetrical and asymmetrical output gains, common mode rejection ratio, offset voltage and current, linearity domains in differential and common modes.
- Analysis of the internal structure of an operational amplifier.

Pre-requisites

Circuit basics; semiconductor physics and PN junctions; transistor amplifier circuits

operational amplifiers and compensation, transistor amplifier circuits

Modeling of magnetic circuits



Component

École Nationale
Supérieure
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** ELP5
- **Open to exchange students:** Yes

Presentation

Description

Modeling magnetic circuits as equivalent electrical circuits, using Hopkinson's analogy, in the case of unsaturated linear circuits. Understanding the origin of the circuit model of the single-phase electrical transformer. Defining the circuit model of the single-phase electrical transformer based on the tests performed. Understanding the circuit model of the stator of electrical machines. Understanding the operation of a three-phase transformer (model, phase rotation, turns ratio).

Components and Architecture



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
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Télécommunications



Semester
Printemps

In brief

- **Ametys Code:** N6EE04
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Semiconductors Physics and PN Junctions	UE				
Signal and Power Transistors	UE				
Course (1 choice out of 2)	UE				
Transistors Amplifier Circuits	UE				
Introduction to Static Conversion	UE				

Semiconductors Physics and PN Junctions



Component

École Nationale
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Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6EE04A
- **Open to exchange students:** Yes

Presentation

Objectives

Integrated circuits are composed of active components whose operation is based on the properties of semiconductor materials (mostly silicon). They represent a compendium of very high-level science and technological development and, at the same time, a factor of socioeconomic progress incomparable since the progress in electricity.



At the end of this module, you will be ready to tackle the operation of all electronic components: principally based on one or more PN junctions or on a Metal/Oxide/Semiconductor (MOS) structure.

Description

All the resources are accessible on the Moodle platform. The theoretical part is divided into 3 parts and is entirely scripted.

If you need or are interested , various links allow you to upgrade:

- In crystallography to better understand the vocabulary used and the calculations made,
- In atomistic, in particular to understand the vocabulary used and the diagrams presented.

The module is composed of:

- 3 classes,
- 1 unsupervised TD during which it is suggested to do exercises whose statements and corrections are on Moodle,
- 1 supervised TD session,
- 1 study desk (over 2 consecutive sessions) to evaluate the skills acquired during this module,
- 1 written test on the knowledge and know-how acquired.

Signal and Power Transistors



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6EE04B
- **Open to exchange students:** Yes

Presentation

Objectives

Present the operation of bipolar transistors, MOS capacitors, and MOS transistors. Write equations derived from physical phenomena. Define the models used in analog circuit design.

Description

Bipolar transistor: Bipolar effect. Current equations for NPN and PNP transistors - Operating modes - Static and dynamic models.

MOS transistor: MOS capacitance: Operating principle, steady-state analysis, dynamic analysis - MOS transistor: operating principle, electrical equations for NMOS and PMOS transistors, switch operation - Introduction to MOS technology

Model synthesis: ideal active component (IAC), real active component (RAC)

Pre-requisites

Semiconductor physics and PN junction

Course (1 choice out of 2)



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N6EE04X
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Transistors Amplifier Circuits	UE				
Introduction to Static Conversion	UE				

Transistors Amplifier Circuits



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6EE04C
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the basic concepts of analog electronics. This course focuses on amplification using bipolar transistors at medium frequencies.

Description

- Study in static conditions: bipolar transistor bias
- Study and characterization of the four dynamic configurations of bipolar transistor amplifiers (common emitter, degenerate common emitter, common collector, common base): equivalent circuit, intrinsic and composite voltage gains, input and output impedances, static and dynamic load lines, harmonic distortion.
- Two-stage amplification: compatibility between stages, impedance adapter, active load.

Pre-requisites

Semiconductor physics and PN junction; circuit basics

Linear operation of the bipolar transistor

Introduction to Static Conversion



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6EE04D
- **Open to exchange students:** Yes

Presentation

Objectives

Students will understand the basic principle of static conversion and analyze the behavior of the step-down transformer chopper.

Description

This course is an introduction to static conversion of electrical energy. The concepts of switching and filtering cells are covered. The operation of non-isolated DC-DC converters is studied. The implementation of a MOS transistor-based step-down converter is carried out in a design office.

Pre-requisites

Methods for studying electrical circuits.

Harmonic analysis.

First-order and second-order electrical circuits: index response and harmonic response.

Teaching unit (1 choice out of 3)



ECTS

 5 credits



Component

 École Nationale

 Supérieure

 d'Électrotechnique

 d'Électronique

 d'Informatique

 d'Hydraulique

 et des

 Télécommunications

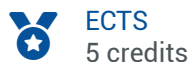
In brief

- > **Ametys Code:** N6EEF
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
CONNECTED OBJECTS	UE				5 credits
Connected Objects	UE				
Connected Objects	UE				
ELECTRICAL PLANE	UE				5 credits
Airplane Electrical Networks	UE				
Basic Structures for C/A and A/C Conversion	UE				
Electromecanic conversion	UE				
Airplane Electrical Networks	UE				
Basic Structures for C/A and A/C Conversion	UE				
Electromecanic conversion	UE				
INTRODUCTION TO TELECOMMUNICATIONS	UE				5 credits
Introduction to Digital Communications	Matière				
Introduction to networks	Matière				

CONNECTED OBJECTS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N6EE05

➤ **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Connected Objects	UE				
	Nature	CM	TD	TP	Crédits
Connected Objects	UE				

Connected Objects



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6EE05A
- **Open to exchange students:** Yes

Presentation

Objectives

Design amplification, filtering, and analog/digital processing chains.

Understand the principle of analog-to-digital conversion.

Understanding the principle of QAM data transmission/reception

Knowing how to analyze data

Learning to work in a group (knowing how to listen to others and actively participate in group work, feeling responsible for everyone's learning)

Learning to manage a project from design to completion

Learning to write a design report

Description

Nowadays, there is a growing demand for the development of sensors to record, quantify, and analyze health status using various criteria. This demand reflects a

sense of poor well-being linked to stress, poor eating habits, and lack of physical exercise. The most common sensors are those related to measuring physical activity via speed, distance traveled, heart rate (using smartphones, smartwatches, etc.). Knowing how much energy we have expended should enable us to better adapt our dietary needs and modify our behavior. Here, we are particularly interested in monitoring heart rate. Until now, this has mainly been measured and obtained by ECG using a chest strap, which was not very comfortable (or using electrodes). In recent years, another more suitable method of measurement has emerged

based on measuring the light absorbed by blood flow: photoplethysmography (PPG) [1]. In addition, it is now also possible to obtain other relevant information about the patient's state of health, such as oximetry [2] [3] and blood pressure [1] [4] [5].

The operating principle is based on a device capable of emitting light within a certain wavelength spectrum (infrared, red, or green) and quantifying the light that is either reflected or absorbed after passing through tissue. It is the variation in blood volume in the blood vessels that modulates the amount of light detected. In general, the most commonly used part of the body is the finger, but it is not limited to this. It can also be the earlobe, the temple, etc.

During this project, students are asked to design the analog/digital part that collects, amplifies, filters, and digitizes the signal from the sensor. It is then transmitted in QAM modulation and processed by signal processing algorithms to bring out the key parameters contained in the signal.

Pre-requisites

Circuit Basics

Logic System Design

Operational Amplifiers and Compensation

Semiconductor Physics and PN Junctions

Signal Transistors and Power Components

Transistor Amplifier Circuits

Digital Signal Processing

Signal Processing

ELECTRICAL PLANE



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6EE06
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Airplane Electrical Networks	UE				
Basic Structures for C/A and A/C Conversion	UE				
Electromecanic conversion	UE				
	Nature	CM	TD	TP	Crédits
Airplane Electrical Networks	UE				
Basic Structures for C/A and A/C Conversion	UE				
Electromecanic conversion	UE				

Airplane Electrical Networks



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6EE06A
- **Open to exchange students:** Yes

Presentation

Objectives

Use the knowledge acquired in electromechanical and static conversion as part of an aircraft electrical on-board network

Description

This module is divided into 2 parts:

- presentation by an Airbus engineer of the future challenges of increasing the role of the electric energy carrier in the aeronautical context (from non-propulsive aircraft systems to propulsion).
- a study will be done at the end of the module, where the students will apply the knowledge acquired on an example of an aeronautical on-board network.

Basic Structures for C/A and A/C Conversion



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6EE06B
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the basic structures of AC-DC and DC-AC power conversion.

Description

Presentation of single-phase and three-phase voltage rectifier topologies using diodes or thyristors.
Presentation of single-phase voltage inverters using full-wave control and pulse width modulation.
Study of the properties of these topologies and waveforms through simulations and experimental models.

Pre-requisites

Methods for studying electrical circuits
Harmonic analysis
Concept of switching cells

Electromecanic conversion



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6EE06C
- **Open to exchange students:** Yes

Presentation

Objectives

This course module aims to familiarize students with the main structures of electrical machines. Ultimately, it should enable them to:

- visually recognize the type of machine (direct current machine, synchronous machine, or asynchronous machine)
- quickly assess the power of an installation incorporating a machine
- familiarize themselves with basic electrical models of machines in order to quickly calculate the electrical and/or mechanical quantities at the machine's input/output
- understand the advantages and disadvantages of using each of the machines studied.

Description

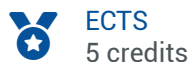
The course covers the basic concepts of DC machines, synchronous machines, and asynchronous machines, which constitute the vast majority of machines used in all areas of electromechanical engineering. After describing the basic architectures, we will present the main characteristics of each of these machines, namely: - characteristic curves highlighting the relationships between torque and speed, voltage and current. This allows students to familiarize themselves with the intrinsic behavior of the machine and thus be able to anticipate a mode of operation.

Pre-requisites

The prerequisites for this course are:

- Calculations of electrical quantities associated with a three-phase electrical network
- Calculations on complex quantities
- Power balance on an electrical system
- the field of application
- equivalent electrical diagrams in order to quickly establish a power balance and calculate the electrical/mechanical quantities required to satisfy an operating point or a task in a targeted application.

INTRODUCTION TO TELECOMMUNICATIONS



In brief

- **Ametys Code:** MHAR35S4
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Introduction to Digital Communications	Matière				
Introduction to networks	Matière				

Introduction to Digital Communications



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** MHAR35XW
- **Open to exchange students:** Yes

Presentation

Objectives

To be able to implement, analyze and optimize simple transmission chains, in baseband and on carrier frequency.

Description

This course presents the fundamentals of the physical layer of a telecommunications system and how to optimize the digital modulator/demodulator block based on the desired bit rate and bit error rate (BER). Digital modulations are studied in baseband (PAM) and on carrier frequencies (ASK, PSK, QAM). Their performance is established in terms of spectral efficiency and power efficiency. To this end, the Nyquist criteria and matched filtering are explained, as well as the concepts of complex envelope and equivalent low-pass filtering. A project provides an introduction to other components of the basic transmission chain: error-correcting coding, synchronization, and equalization.

Pre-requisites

Signal processing and digital signal processing

Introduction to networks



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** MHAR363Q
- **Open to exchange students:** Yes

Presentation

Objectives

The aim of this course is to provide a solid understanding of the fundamental principles of computer networking, with an emphasis on local area networks (LANs) and Internet communication protocols. Through a theoretical and practical approach, students will learn how data is exchanged within a network, how devices interact, and how different protocol layers work together to ensure reliable and efficient communication.

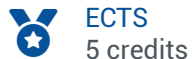
Description

Upon completion of this course, students will be able to:

- Understand the different methods of accessing shared media (e.g., ALOHA, CSMA, Token Ring).
- Identify and analyze data link layer protocols (Ethernet, Wi-Fi).
- Understand the operating mechanisms of the Internet: IP addressing, routing, fragmentation, transport protocols (TCP/UDP), application services (DNS, HTTP).
- Configure and troubleshoot a simple network using practical tools (Wireshark, virtual routers, etc.).

- Compare and simulate different types of multiple access. This course combines theory (lectures/tutorials) and practical application (labs) to consolidate knowledge and develop operational skills.

SOFT AND HUMAN SKILLS 2



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M4IJYC4P

List of courses

	Nature	CM	TD	TP	Crédits
Élément à choix UE SHS S6 FISE	Élément constitutif				
English	Matière				
Sports	Matière				
Leadership Part 1 - S6	Matière				
Leadership Part 2 - S6	Matière				
Entrepreneurship Part 1 - S6	Matière				
Entrepreneurship Part 2 - S6	Matière				
Citizenship Part 1 - S6	Matière				
Citizenship Part 2 - S6	Matière				
Agile methods	Matière				
Managership P1-S6	Matière				
Managership P2-S6	Matière				
Spanish	Matière				
Portuguese	Matière				
Chinese	Matière				
Italian	Matière				
Japonese	Matière				
Russian	Matière				
German	Matière				
French as a Foreign Language	Matière				
FSL - S6	Matière				

Élément à choix UE SHS S6 FISE



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M23F371L

List of courses

	Nature	CM	TD	TP	Crédits
English	Matière				
Sports	Matière				
	Nature	CM	TD	TP	Crédits
Leadership Part 1 - S6	Matière				
Leadership Part 2 - S6	Matière				
Entrepreneurship Part 1 - S6	Matière				
Entrepreneurship Part 2 - S6	Matière				
Citizenship Part 1 - S6	Matière				
Citizenship Part 2 - S6	Matière				
Agile methods	Matière				
Managership P1-S6	Matière				
Managership P2-S6	Matière				
	Nature	CM	TD	TP	Crédits
Spanish	Matière				
Portuguese	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
French as a Foreign Language	Matière				
FSL - S6	Matière				

English



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **plugin.odf-inp:PLUGINS_ODF_COURSE_NBHOURS_TXT:** 21
- **Ametys Code:** N6EK01A

Presentation

Objectives

Develop professional communication competencies by completing key written and oral tasks in English.

Description

1 semester of 12 interactive, weekly sessions in English.

Pre-requisites

None

Sports



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6EK01C
- **Open to exchange students:** No

Presentation

Objectives

- Health seen as a set of resources that need to be mobilized and developed.
- Self-knowledge through effort.
- Access to a cultural domain.

Description

- Choose a sport from a list of twenty or so (activities to suit all tastes).
- A weekly sports slot.
- Training and Cross at the end of semester 1.

Leadership Part 1 - S6



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M23F37SV
- **Open to exchange students:** No

Presentation

Objectives

1. Explore the concept of sustainable development & civic engagement.
2. Extend knowledge of different examples, workplace activities & issues, frameworks.
3. Study the concepts of life cycle analysis, eco-design, decarbonization.
4. Apply key concepts to a team civic engagement project proposal.
5. Present and defend a team civic engagement project proposal.

Description

By the end of the module, students will have :

- # effectively planned and executed projects using traditional methods, focusing on aspects such as Gantt charts, critical path analysis, and resource allocation.
- # analyzed and compared basic project management approaches with other methodologies, particularly understanding the context in which project management is most effective.
- # applied basic project management techniques to real-world or simulated case studies.

efficiently conducted and facilitated meetings with project clients and stakeholders,
focusing on techniques to maximize time and cost efficiency.

Leadership Part 2 - S6



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M23F37VT
- **Open to exchange students:** No

Presentation

Objectives

1. Raise awareness of diversity issues in the workplace and the topics that need to be addressed in order to improve equality
2. Identify the impact of empathy and mindful leadership styles
3. Enhance the capacity to make difficult decisions, particularly in sensitive or ambiguous situations
4. Develop critical thinking, analytical and professional communication soft skills.

Description

By the end of this 5-week course students will have

- # gained a comprehensive understanding of what leadership is and how to become an effective leader;
- # participated in a diversity serious game and gained insights into diversity topics relevant to leaders;
- # reflected on ethical scenarios which can arise in a workplace, and how to best manage issues with integrity

developed their professional networking and communication skills to interview a mentor about leadership and diversity in their workplace with the view to gaining experiential insights.

Engaged in leadership role plays to gain insights into the multi dimensional aspects of considerations that need to be taken into account when leading with diversity

Entrepreneurship Part 1 - S6



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M23F37ZZ
- **Open to exchange students:** No

Presentation

Objectives

Develop basic entrepreneurial knowledge and skills

.

Session 1 + 2: Basic financial management (costs, revenues, profitability)

- # Understanding financial indicators
- # Strategic financial decision-making
- # Ability to analyze and plan budgets
- # Autonomy in managing your business.

Session 3 + 4: Presenting your project

- # Communication skills and storytelling
- # Structuring and clarity of speech
- # Effective pitch techniques
- # Stress management and public speaking
- # Synthesis and persuasion skills.

Session 5 + 6: Creating opportunities and integrating into an ecosystem :

- # Developing your professional network
- # Identifying and exploiting opportunities
- # Negotiation skills and partnership relations

- # Entrepreneurial spirit and proactive posture
- # Ability to receive and integrate feedback

Translated with DeepL.com (free version)

Description

By the end of this module, students will have adopted a 'design thinking' entrepreneurial approach to develop the basic knowledge and skills relating to their entrepreneurial posture.

Entrepreneurship Part 2 - S6



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M23F383B
- **Open to exchange students:** No

Presentation

Objectives

Key Skills to be developed:

Foundational financial knowledge

Practical tools for entrepreneurial decision-making

Analytical skills for interpreting financial data.

Description

This course helps students gain essential financial knowledge and skills to adopt an entrepreneurial mindset, focusing on fundamental concepts of accounting, financial analysis, and decision-making.

Citizenship Part 1 - S6



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M23F3860
- **Open to exchange students:** No

Presentation

Objectives

Are you one of those people who believe that SHS (Humanities and Social Sciences) are not "real sciences", like mathematics or physics?
Do you believe that everything teachers say is true
? Do you believe that most knowledge is acquired by reading texts? If so, you probably have a somewhat naive view of science.
This course is designed to help you take stock of your beliefs about knowledge and science - what we call epistemological beliefs. By the end of this course, you'll be able to take an (even) more critical look at knowledge, the sciences, teachers and the subjects you're taught at school.

Description

1. At the end of Part #1, students will be able to analyze their personal conception of science. They will take a critical look at their personal vision of certain aspects of scientific knowledge such as, for example, the empirical, theoretical, creative and imaginative nature of scientific knowledge, its social and cultural roots, and its provisional nature

2. At the end of Part #2, students will develop their own definition of engineering as an applied science.

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3. By the end of Part #3, students will draw up an inventory of the epistemological factors they believe influence the constitution of a knowledge base in engineering.
ingénierie.

Citizenship Part 2 - S6



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M23F389W
- **Open to exchange students:** No

Presentation

Objectives

Familiarize yourself with the notion of Corporate Social Responsibility, understand its foundations and the associated societal issues.

Be able to analyze and evaluate a company's overall CSR approach.

Learning outcomes: By the end of this course, students will have mastered concepts and multidisciplinary methodological tools enabling them to - -

characterize the conditions for implementing a CSR approach;

diagnose the CSR approach and identify options for improvement.

Description

Comparative case studies of companies that have developed a CSR approach (summary of 4 pages and oral presentation).

Agile methods



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M23F38CW
- **Open to exchange students:** No

Presentation

Description

Develop your knowledge and skills in project management and agile methods.

Managership P1-S6



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M23F38GB
- **Open to exchange students:** No

Presentation

Objectives

1. To gain an awareness of key topics related to organizational and managerial & features;
2. To understand key organizational and management phenomena experienced in professional life;
3. To put theoretical input into practice, and use tools and analytical grids to understand current companies and their related developments.

Description

By the end of the module, students will have developed:

Knowledge: students will be able to name key generic characteristics of organizational structure, culture and managerial processes and how they influence daily organizational and managerial action.

Know-how: students will be able to analyze organizational and managerial features to understand how they function, their intertwinement, and impacts on the daily functioning of companies.

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Managerial competencies: interpersonal abilities through team work (case study and collective analysis), particularly negotiation, managing possible disagreements, articulating and expressing their thoughts to others.

Other competencies: oral presentation skills in a professional format, summarizing the results of their analysis and rephrasing them in public; defending their arguments, analysis and findings.

Managership P2-S6



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M23F38JM
- **Open to exchange students:** No

Presentation

Objectives

Learning objectives:

- # Identify your own profile and those of others to improve collaboration and understanding;
- # Identify the strengths of your soft skills (EQ-I) to use them in the team setting;
- # Develop your ability to communicate effectively using your strengths.
- # Regulate conflicts.
- # Develop cross-functional skills
- # Managerial skills addressed and worked on
- # Speaking in front of a group, posture and ability to convince and debate
- # International - The concepts of management leadership, team cohesion and soft skills as used are derived from international work and research.
- # Social and environmental responsibility - Understanding the issues of Quality of Life at Work and psychosocial risks thanks to the concepts covered in

emotional intelligence and soft skills development.

Description

Learning outcomes: At the end of this intervention, the student will have

- # have identified their personal functioning and potential;
- # will have identified his or her managerial posture, particularly in managing conflicts;
- # be able to regulate stress more easily.

Spanish



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6EK01BA
- **Open to exchange students:** No

Presentation

Description

Develop professional communication competencies by completing key written and oral tasks in Spanish.

Portuguese



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6EK01BB
- **Open to exchange students:** No

Presentation

Description

Develop professional communication competencies by completing key written and oral tasks in portuguese.

Chinese



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6EK01BC
- **Open to exchange students:** No

Presentation

Description

Develop professional communication competencies by completing key written and oral tasks in Chinese.

Italian



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6EK01BD
- **Open to exchange students:** No

Presentation

Description

Develop professional communication competencies by completing key written and oral tasks in italian.

Japanese



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6EK01BE
- **Open to exchange students:** No

Presentation

Description

Develop professional communication competencies by completing key written and oral tasks in Japanese.

Russian



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6EK01BF
- **Open to exchange students:** No

Presentation

Description

Develop professional communication competencies by completing key written and oral tasks in russian.

German



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6EK01BG
- **Open to exchange students:** No

Presentation

Description

Develop professional communication competencies by completing key written and oral tasks in german.

French as a Foreign Language



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6EK01BH
- **Open to exchange students:** No

Presentation

Description

Develop your professional communication skills by performing common written and oral communication tasks in French as a foreign language.

FSL - S6



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M23F3AG1
- **Open to exchange students:** No

Presentation

Description

Develop your professional communication skills by performing common communication tasks and gestures in French Sign Language.

Semestre 7 - Electronics (EN)



ECTS
30 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M8FQ4WAJ
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
RADIOFREQUENCY ANALOG ELECTRONICS	UE				5 credits
RF Active Circuits	UE				
PLL and Oscillators	UE				
Analog Filtering	UE				
TP Advanced Design System (ADS)	UE				
LOW FREQUENCY ANALOG ELECTRONICS	UE				5 credits
Amplification classes	UE				
Analog Project	UE				
DIGITAL ELECTRONICS	UE				5 credits
VHDL	UE				
Front-End instrumentation	UE				
ELECTROMAGNETIC PROPAGATION	UE				5 credits
Guided propagation	UE				
Ideal Passive Circuits	UE				
Transmission Lines	UE				
INFORMATION PROCESSING	UE				5 credits
Random Signals	UE				
Object-Oriented Programming (POO)	UE				
Microprocessor	UE				
SOFT AND HUMAN SKILLS	UE				5 credits
Professional English 2.1 : Presentations	Matière				
2nd language	Bloc				
Spanish	Matière				
Spanish	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
French as a Foreign Language	Matière				
LSF - S7	Matière				
Sports	Matière				
Leadership & Management	Matière				

RADIOFREQUENCY ANALOG ELECTRONICS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7EE06
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
RF Active Circuits	UE				
PLL and Oscillators	UE				
Analog Filtering	UE				
TP Advanced Design System (ADS)	UE				

RF Active Circuits



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7EE06A
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of this course, students will be able to:

- Define the specifications of an amplifier.
- Choose amplifier architectures that meet their specifications.
- Design amplifiers that meet criteria for power gain, linearity, noise, and power efficiency.

Description

This course provides students with the knowledge they need to design RF amplifiers using hybrid and integrated (MMIC) technology.

Microwave technology

RF amplifiers:

HEMT: operation, IV characteristics

Linearity: P&dB, IP3, C/I3

Efficiency, PAE

Choice of amplification class

Transistor stability

Amplifier design:

Power matching

Fluence graphs

Gain optimization

Broadband amplifiers

Design example

Fixed-gain amplifier

Low-noise amplifier

Oscillators

Pre-requisites

Transmission lines (N7EE09D)

PLL and Oscillators



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7EE06B
- **Open to exchange students:** Yes

Presentation

Objectives

By the end of this course, students will be able to:

- Understand the fundamental principles of phase-locked loops (PLLs) and oscillators.
- Identify the different types of phase detectors and their areas of application.
- Master the role and operation of voltage-controlled oscillators (VCOs) and charge pumps in a PLL.
- Analyze the dynamics of the loop in capture mode and locked mode, as well as the conditions for stability.
- Design and characterize loop filters in relation to the overall performance of the PLL (bandwidth, noise, lock time).
- Understand the principle of positive feedback oscillators, harmonic and LC oscillators, and the concept of negative resistance.
- Be familiar with quartz oscillators and their frequency stability characteristics.

Description

1. General introduction to PLLs and oscillators

Reminder of synchronization and frequency generation requirements in electronic systems.

Basic architecture of a phase-locked loop (PLL): phase detector, loop filter, voltage-controlled oscillator (VCO), frequency divider, charge pump.

Areas of application: telecommunications, data conversion, processor clocks, RF circuits.

2. Phase detectors and associated circuits

Phase multiplier: analog operation.

XOR detector: logical approach and simple applications.

Flip-flop detector: sequential phase detection.

PFD (Phase-Frequency Detector): detailed operation, linearity, wide capture range.

Charge Pump: current-voltage conversion, imbalance effects, and impact on phase noise.

3. Loop filter and PLL dynamics

Structure and role of the loop filter: integrator, active/passive low-pass filter.

Analysis of the PLL in locked mode: stability, phase margin, frequency response.

Analysis of the PLL in capture mode: transient dynamics, phase acquisition.

Concepts of bandwidth, lock time, and jitter.

4. Voltage-controlled oscillators (VCO)

Principle of operation of the VCO.

Voltage/frequency relationship and linearity.

5. Principles of autonomous oscillators

Oscillation conditions and positive feedback.

Harmonic and LC oscillators: topologies, stability, spectral purity.

The concept of negative resistance: energy interpretation and practical implementation.

Quartz oscillators: resonance principle, frequency stability, app

Pre-requisites

Signal transistors and power components

Transistor amplifier circuits

Continuous linear systems automation

Methods for analyzing electrical circuits

Analog Filtering



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7EE06C
- **Open to exchange students:** Yes

Presentation

Objectives

Upon completion of this course, students will be able to:

- understand the role of filters in complex transmission/reception systems
- determine filter specifications
- develop a family of stable network functions that meet phase or amplitude characteristics
- size an LC filter according to specifications
- apply passive or active filter synthesis techniques

Description

- Study of a Tx/Rx system
- Concept of network functions

- Determination of a partially known stable function $f(p)$
- Positive and real functions and passive dipoles
- Synthesis of passive dipoles
- Passive filters
- Active filters

Pre-requisites

None

TP Advanced Design System (ADS)



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

> **Ametys Code:** N7EE06D

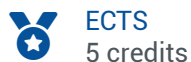
Presentation

Description

Labwork using the software Agilent Advanced Design System

Applications of the concepts introduced in Passive RF circuits and Active RF circuits

LOW FREQUENCY ANALOG ELECTRONICS



In brief

- **Ametys Code:** N7EE07
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Amplification classes	UE				
Analog Project	UE				

Amplification classes



Component

École Nationale
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d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7EE07B
- **Open to exchange students:** Yes

Presentation

Objectives

The aim is to learn how to design power amplifiers to achieve maximum efficiency.

Description

In order to interact with the world around us, it is often necessary to deliver significant power to the load, which may be an electromechanical object to set it in motion (speakers, motors, piezoelectric elements, etc.), or an antenna to transmit over long distances. This task falls to the output stage of an amplifier that is directly connected to this load. The amplifier must therefore be capable of delivering a high-power signal without deteriorating its properties.

The output stage must also have the following properties:

- Low output impedance so that the impedance of the output load does not generate a loss of gain.
- Provide high-amplitude signals (in voltage and current).

- Distort the signal as little as possible when dealing with high-amplitude signals (to be compared with small-signal studies in linear electronics to achieve the amplification function).
- Transfer power to the load with maximum efficiency, which means that the power dissipated by the output stage must be as low as possible. This is all the more important today in order to make battery-powered devices more autonomous.
- Be able to dissipate power without deteriorating the performance of its active components

Pre-requisites

Signal transistors and power components

Transistor amplifier circuits

Continuous linear systems automation

Methods for analyzing electrical circuits

Analog Project



Component

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d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7EE07C
- **Open to exchange students:** Yes

Presentation

Objectives

The objective of the project is to transmit an audio signal (speech or music) over a distance via a wireless link. This is achieved using an infrared optical beam ($\lambda=900\text{nm}$) transmitted through the air. In addition to the audio source (e.g., a cell phone) and the speaker or headphones, the device comprises two units: a transmitter and a receiver.

Description

The transmitter mainly comprises a voltage-controlled oscillator (VCO) whose frequency varies linearly with the amplitude of the input signal. The center frequency f_0 must be relatively high compared to the highest FM audio frequency of the signal to be transmitted. The light flux containing the information to be transmitted is emitted by a high-efficiency light-emitting diode (LED) whose intensity is proportional to its instantaneous bias current in the modulation frequency range. A preamplifier-filter processes the audio modulating signal to be transmitted before applying it to the VCO input.

The receiver has a silicon PIN photodiode at its input, whose spectral response is adapted to the LED's emission spectrum. This photoreceptor generates a photoelectric current proportional to the intensity of the received light flux. The photoelectric current is amplified by a transimpedance circuit, which produces an output voltage proportional to the input alternating current. A high-gain selective amplifier amplifies the photoelectric signal and feeds it to a discriminator, which performs the frequency-to-voltage

conversion. A phase-locked loop (PLL) is used for this purpose. After filtering the audio signal, a class AB push-pull audio amplifier drives a loudspeaker or headphones.

Pre-requisites

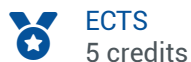
Signal transistors and power components

Transistor amplifier circuits

Continuous linear systems automation

Methods of analyzing electrical circuits

DIGITAL ELECTRONICS



In brief

- **Ametys Code:** N7EE08
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
VHDL	UE				
Front-End instrumentation	UE				

VHDL



Component

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d'Informatique
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Télécommunications

In brief

- **Ametys Code:** N7EE08A
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand the fundamentals of digital design and the VHDL language.
- Model simple combinational and sequential circuits using VHDL.
- Simulate and synthesize circuits using EDA tools (e.g. Vivado).
- Learn best practices for VHDL coding and documentation.

Description

This course introduces students to digital circuit design using VHDL (VHSIC Hardware Description Language). It covers basic syntax, circuit modeling, simulation, and synthesis for FPGAs. Students will learn to describe combinational circuits (logic gates, multiplexers, decoders) and sequential circuits (flip-flops, registers, state machines), and use EDA tools to validate their designs.

Pre-requisites

- Basic knowledge of digital electronics (Boolean algebra, logic gates, flip-flops).

- Familiarity with a programming language (C, Python, etc.) is helpful but not required.

Front-End instrumentation



Component

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Télécommunications

In brief

- **Ametys Code:** N7EE08B
- **Open to exchange students:** Yes

Presentation

Objectives

By the end of this course, students will be able to:

- Understand the fundamental principles of analog-to-digital (ADC) and digital-to-analog (DAC) conversions.
- Analyze sources of noise and error in instrumentation chains, including quantization noise and spectral aliasing.
- Design and size appropriate anti-aliasing filters, particularly using switched-capacitor filters.
- Select and configure components (ADCs, DACs, filters) based on application requirements.
- Evaluate the performance of signal acquisition or generation chains.

Description

This course covers the principles and challenges of signal conversion and processing in instrumentation chains. Key topics include:

- **Analog-to-Digital (ADC) and Digital-to-Analog (DAC) Conversion:** Architectures (flash, SAR, sigma-delta, etc.), resolution, speed, and limitations.
- **Noise and Errors:** Quantization noise, signal-to-noise ratio (SNR), total harmonic distortion (THD), and spectral aliasing.
- **Associated Filtering:** Design of anti-aliasing filters, switched-capacitor filters, and digital filters (FIR, IIR).

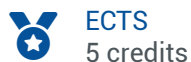
- **Practical Applications:** Case studies on acquisition chains (sensors, conditioning, ADC) and signal generation (DAC, reconstruction, filtering).
- **Tools and Methods:** Use of simulation software (PSpice, MATLAB) and measurement instruments (oscilloscope, spectrum analyzer).

The course combines theoretical lectures, tutorials, and lab sessions to apply concepts to real-world problems.

Pre-requisites

- Basic knowledge of analog electronics (operational amplifiers, passive and active filters).
- Familiarity with signal processing concepts (Fourier transform, sampling).
- Experience with simulation software (PSpice, MATLAB).
- Basic knowledge in FPGA programming (VHDL, Vivado)

ELECTROMAGNETIC PROPAGATION



In brief

- **Ametys Code:** N7EE09
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Guided propagation	UE				
Ideal Passive Circuits	UE				
Transmission Lines	UE				

Guided propagation



Component

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d'Électronique
d'Informatique
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Télécommunications

In brief

- **Ametys Code:** N7EE09A
- **Open to exchange students:** Yes

Presentation

Objectives

Know how to physically analyze the interaction of a plane electromagnetic wave with a dielectric interface.

- Know how to perform an electromagnetic power balance in free space.
- Know the main properties of a plane wave.
- Know what the Brewster angle refers to.
- Know what a mode in a waveguide refers to.
- Know what cutoff frequency means.
- Know what dispersion means.
- Know how to calculate the power carried by a propagative mode in a waveguide.
- Know how to calculate the energy stored by an evanescent mode in a waveguide.

- Know how to perform a power balance in guided electromagnetic propagation.

Description

I- Reminders: Laws of electromagnetism

I-1- Concept of instantaneous electromagnetic fields

I-2- Maxwell's equations

I-3- Harmonic regime in electromagnetism

I-4- Average power density and energy in electromagnetism

II- Electromagnetic propagation in free space

II-1- Modes in free space: concept of plane waves

II-2- Electromagnetic field of a plane wave and main properties

II-3- Law of conservation of electromagnetic energy in free propagation

II-4- Group and phase velocities of a plane wave

II-5- Example: Reflection and transmission coefficients of a plane

and static dielectric surface

III- Guided electromagnetic propagation

III-1- Guided propagation mode: concept of propagative and evanescent modes

III-2- Dispersion phenomenon in electromagnetism

III-3- Electromagnetic field of a mode and main properties

III-4- Law of conservation of electromagnetic energy in guided propagation

III-5- Group and phase velocities of a mode

III-6- Example: Rectangular guide with electric or magnetic walls

Pre-requisites

The content of the review (section I of this subject), namely (1) Maxwell's equations (classical laws of electromagnetism), (2) the constitutive equations of any medium, and (3) harmonic regime

Ideal Passive Circuits



Component

École Nationale
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Télécommunications

In brief

- **Ametys Code:** N7EE09B
- **Open to exchange students:** Yes

Presentation

Objectives

Upon completion of this course, students will be able to:

- Implement distributed passive functions (using transmission lines)
- Understand the difficulties associated with the use of distributed techniques
- Predict the electrical behavior of functions
- Propose function architectures that meet specifications
- Implement passive multipole synthesis techniques

Description

RF spectrum and applications

Filter integration:

- Stub filters
- Impedance jump filters
- Impedance inverters-based filters
- Coupled line filters

Multipoles :

- Divider
- Coupler
- Hybrid couplers
- Proximity couplers
- Coupler applications: Attenuators, phase shifters, mixers, balanced circuits

Transmission Lines



Component

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In brief

- **Ametys Code:** N7EE09D
- **Open to exchange students:** Yes

Presentation

Objectives

In this course, students learn about Smith charts and their uses in circuit resolution and matching techniques.

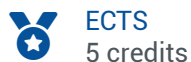
Description

The course is divided into three parts. Video materials are available between sessions to explore certain concepts in greater depth or to improve understanding.

Pre-requisites

The Electromagnetism course and the Propagation in Lines course in the first year.

INFORMATION PROCESSING



In brief

- **Ametys Code:** N7EE10
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Random Signals	UE				
Object-Oriented Programming (POO)	UE				
Microprocessor	UE				

Random Signals



Component

École Nationale
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d'Électronique
d'Informatique
d'Hydraulique
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Télécommunications

In brief

- **Ametys Code:** N7EE10A
- **Open to exchange students:** No

Presentation

Objectives

The objective of this course is to revisit concepts covered in the first year of EEEA concerning the processing of deterministic signals and to see how these concepts can be generalized to random signals (also called random processes). These generalizations make it possible to define the adapted filter (widely used in telecommunications) and the Wiener filter (used in image processing). Part of the course focuses on the study of nonlinear transformations of random signals and Poisson processes.

Description

Spectral analysis (autocorrelation and spectral density), filtering and sampling of random signals with a particular focus on the matched filter and the Wiener filter. Non-linear processing of random signals. Signals constructed using Poisson processes

Object-Oriented Programming (POO)



Component

École Nationale
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In brief

- **Ametys Code:** N7EE10B
- **Open to exchange students:** Yes

Presentation

Objectives

Introduction to the basic concepts of object-oriented design and programming, illustrated using the C++ language.

Description

This course consists mainly of work on an object-oriented programming project involving electronic circuit simulation, preceded by a few supervised and independent practical sessions to acquire the basic concepts.

General characteristics of object-oriented languages (encapsulation, classification, inheritance, polymorphism, dynamic linking, etc.) – The basics of C++ programming (typing, program structure, references, etc.) – The specific features of object-oriented programming in C++ (classification and inheritance, input/output, exceptions, templates).

Pre-requisites

C language. First-year EEEA course in Algorithms and Programming Methods.

Microprocessor



Component

École Nationale
Supérieure
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7EE10C
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand the **internal operation of a microprocessor and a microcontroller**.
- Distinguish fundamental concepts such as **sampling, quantization, resolution, memory organization, data buses, and instruction cycles**.
- Be able to **describe the architecture of a microcontroller**, particularly the **PIC families** (8-, 16-, and 32-bit).
- Learn how to **program a microcontroller** at a low level:
 - Understanding of **assembly language**,
 - Introduction to **C programming** for embedded systems.
- Be capable of **configuring and using internal peripherals** such as timers, ADCs, GPIO ports, UART, SPI, and interrupts.

Description

This course is a **comprehensive introduction to embedded microelectronics**.

It covers:

1. The **basic principles** of digital systems (sampling, quantization, buses, and memory).

2. The **detailed operation of a microprocessor**: arithmetic and control units, instruction cycles, and instruction sets.
3. **Memory types and hierarchy**: RAM, ROM, EEPROM, Flash, and their characteristics.
4. **PIC Microcontrollers**:

- **Harvard vs Von Neumann** architectures
- **RISC vs CISC** concepts
- Memory organization and **interrupt handling**
- On-chip peripherals: **I/O ports, timers, ADC, UART, SPI**, etc.
- Practical **assembly and C code examples** for PIC18 and PIC24.

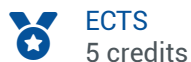
The course combines **theory and hands-on practice**, focusing on understanding hardware architecture and low-level programming.

Pre-requisites

To follow this course effectively, students should have:

- Solid knowledge of **digital electronics** (bits, buses, binary logic).
- Basic understanding of **logic circuits and system architecture**.
- Some experience with **C programming** (variables, loops, syntax).
- An interest in **embedded systems** and **processor-level operation**.

SOFT AND HUMAN SKILLS



In brief

- > **Ametys Code:** N7EK01
- > **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Professional English 2.1 : Presentations	Matière				
2nd language	Bloc				
Spanish	Matière				
Spanish	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
French as a Foreign Language	Matière				
LSF - S7	Matière				
Sports	Matière				
Leadership & Management	Matière				

Professional English 2.1 : Presentations



Component
École Nationale
Supérieure
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d'Électronique

In brief

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- **Ametys Code:** N7EK01A

Presentation

Objectives

Perform key oral and written workplace tasks in English.

Description

A semester of 12 interactive weekly sessions to develop English intercultural communication competencies for professional purposes.

Pre-requisites

None.

2nd language



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N7EK01B
- **Open to exchange students:** No

Presentation

Description

Develop professional communication skills by performing common written and oral communication tasks in foreign languages other than English.

List of courses

	Nature	CM	TD	TP	Crédits
Spanish	Matière				
Spanish	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
French as a Foreign Language	Matière				
LSF - S7	Matière				

Spanish



Component
École Nationale
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d'Électronique

In brief

➤ **Ametys Code:** N7EK01BA

Spanish



Component
École Nationale
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d'Électronique

In brief

➤ **Ametys Code:** N7EK01BB

Chinese



Component
École Nationale
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d'Électronique

In brief

➤ **Ametys Code:** N7EK01BC

Italian



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N7EK01BD

Japanese



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N7EK01BE

Russian



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N7EK01BF

German



Component
École Nationale
Supérieure
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d'Électronique

In brief

➤ **Ametys Code:** N7EK01BG

French as a Foreign Language



Component
École Nationale
Supérieure
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d'Électronique

In brief

➤ **Ametys Code:** N7EK01BH

LSF - S7



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M4R9TM1A

Sports



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N7EK01C
- **Open to exchange students:** No

Presentation

Description

Physical Education & Sport courses are scheduled over 4 semesters consisting of 80 hours of face-to-face training maximum. They are organized by the INP Department of Physical Education and Sport (Département d'Éducation Physique et Sportive, DEPS-INP) which also proposes participation in numerous university tournaments and events. There is a dynamic student sports association which offers a wide range of activities throughout the school year.

Leadership & Management



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique



**Number of
hours**
21h

In brief

- **Ametys Code:** N7EK01D
- **Open to exchange students:** No

Presentation

Objectives

1. Build on personal professional project groundwork from L3 semesters 1 and 2;
2. Update & develop related documents, carry out research on the chosen industrial sector, measure needs & opportunities, & interview engineers from the network to discover more about their day-to-day professional activities;
3. Reflect on later career stages and on their selected paths and other options;
4. Present and defend their project to a jury composed of teacher-researchers, human resources experts and industrial partners;
5. Garner feedback from experienced professionals and extend their network.

Description

By the end of the module, students will have:

- # assembled and reflected on previous PPP groundwork & developed related artefacts to showcase their skills effectively;
- # conducted exploratory documentary & interview research in a chosen engineering sector to compare & contrast professional opportunities;
- # used specific PPP tools proposed;
- # given a formal PowerPoint presentation of a chosen career path and its options, matching a specific personal profile and industrial needs in a given sector;

produced accompanying professional artifacts (CV, letter etc.) integrating company partner recommendations & advice.

Semestre 7 - Electronics, Electrical Energy and Simulations (EEES)



ECTS
30 credits



Component
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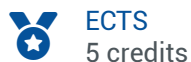
In brief

- **Ametys Code:** M8FQ69YJ
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
ELECTROMAGNETIC PROPAGATION	UE				5 credits
Guided propagation	UE				
Ideal Passive Circuits	UE				
Transmission Lines	UE				
COMPUTER SCIENCE AND ANALOG FILTERING	UE				5 credits
Analog Filtering	UE				
Object-Oriented Programming (POO)	UE				
Reliability of numerical calculations	Matière				
SCIENTIFIC COMPUTING FOR ELECTRICAL ENGINEERING	UE				5 credits
Random Signals	UE				
Numerical analysis	Matière				
Numerical Methods for PDE	Matière				
POWER ELECTRONIC COMPONENTS AND MECATRONIC	UE				5 credits
Electro-megneto-thermal modeling and simulation of power electronic components	Matière				
Principle and structure of machines	Module				
ELECTRICAL MACHINE MODELING AND NUMERICAL SIMULATION	UE				5 credits
Electromagnetic modeling of machines	UE				
Numerical experiences	Matière				
SOFT AND HUMAN SKILLS	UE				5 credits
Professional English 2.1 : Presentations	Matière				
2nd language	Bloc				
Spanish	Matière				
Spanish	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
French as a Foreign Language	Matière				
LSF - S7	Matière				
Sports	Matière				
Leadership & Management	Matière				

COMPUTER SCIENCE AND ANALOG FILTERING



In brief

- **Ametys Code:** N7EE13
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Analog Filtering	UE				
Object-Oriented Programming (POO)	UE				
Reliability of numerical calculations	Matière				

Reliability of numerical calculations



Component

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In brief

- **Ametys Code:** N7EE13A
- **Open to exchange students:** Yes

Presentation

Objectives

The aim of the course is to introduce students to errors caused by calculations performed on computers using floating point arithmetic. It also aims to present methods for improving or guaranteeing the accuracy of numerical results.

Description

This module introduces single and double precision number representation and explains error phenomena related to floating point calculations, such as cancellation and absorption errors. Using concrete examples, such as calculating derivatives using finite differences, students observe how rounding errors influence results. The course then presents several approaches to improving reliability: quadruple precision, exact decimal arithmetic, interval arithmetic, and stochastic arithmetic. Finally, an introduction to deterministic global optimisation by intervals shows how these techniques can be used to obtain numerically guaranteed solutions. The entire module alternates between lectures and practical work to provide both a theoretical and experimental understanding of the challenges of numerical computation.

Pre-requisites

- Knowledge of MATLAB or Python languages for implementation
- Basic understanding of numerical conditioning or errors (not mandatory but useful)
- Knowledge of some numerical methods such as integral calculus, finite difference derivatives or optimisation (not mandatory but useful)

SCIENTIFIC COMPUTING FOR ELECTRICAL ENGINEERING



ECTS
5 credits



Component
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Télécommunications

In brief

- **Ametys Code:** N7EE14
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Random Signals	UE				
Numerical analysis	Matière				
Numerical Methods for PDE	Matière				

Numerical analysis



Component

École Nationale
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HL09P
- **Open to exchange students:** Yes

Presentation

Objectives

Discover the principle and properties of two concepts that form the basis of many numerical analysis tools: numerical quadrature and interpolation.

Description

The definition and basic properties are given for numerical quadrature and interpolation. A tutorial session is offered to practise some of these concepts. A practical session allows students to implement some of the methods presented using examples. Assessment is based on the practical session report.

Numerical Methods for PDE



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N7EM04B
- **Open to exchange students:** Yes

Presentation

Objectives

- Introduction to the methods of resolution of linear systems applied to numerical methods for solving a partial differential equation (PDE).
 - From an existing code solving a 2D advection-diffusion PDE (language: Fortran 90, explicit scheme), modify it in order to use implicit scheme.
-

Description

Teaching (2 classes):

- Explicit/implicit scheme, finite-volume method
- Introduction to direct/iterative methods for solving linear systems

Project (8 classes):

- getting use to the explicit code
- writing of the implicit scheme

- implementation and exploitation of the implicit scheme

Pre-requisites

- Notions in the numerical analysis of partial differential equations.
- Notions programming (python, C, fortran, etc)
- Notions regarding the finite volume method

Useful info

Contacts

Responsable pédagogique

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POWER ELECTRONIC COMPONENTS AND MECATRONIC



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HMSRQ
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Electro-megneto-thermal modeling and simulation of power electronic components	Matière				
Principle and structure of machines	Module				

Electro-megneto-thermal modeling and simulation of power electronic components



Component

École Nationale
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d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HKRB2
- **Open to exchange students:** Yes

Presentation

Objectives

Acquire the knowledge and skills necessary to model, simulate and analyse the electromagnetic and thermal behaviour of power electronic devices. Understand the multiphysical interactions that influence the performance, reliability and design of devices.

Description

This course covers coupled electromagnetic-thermal modelling of power electronics components. It addresses the fundamental principles of electrical conduction, electromagnetic fields, and heat transfer, as well as their integration into comprehensive multiphysics models. Experimental manipulations will be used to characterise components and identify their electrical and thermal parameters, while numerical simulations performed with tools such as COMSOL and PLECS will be used to analyse losses, heating and electromagnetic stresses in power devices.

Pre-requisites

basic knowledge of electrical engineering, magnetism and power electronics.

Principle and structure of machines



Component

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Télécommunications

In brief

- **Ametys Code:** ELP6
- **Open to exchange students:** Yes

Presentation

Objectives

- Explain the physical principles of electromechanical energy conversion.
- Identify and describe the main structures of electrical machines (stator, rotor, windings, magnetic circuits, etc.).
- Differentiate between types of machines according to their operating principles (DC, AC, synchronous, asynchronous).
- Qualitatively analyze the electromagnetic and mechanical behavior of a machine based on its equivalent circuit.

Description

This course presents the operating principles and basic structures of the main electrical machines used in modern industrial electromechanical and energy systems (DC machines, alternators, asynchronous motors, synchronous motors, etc.) and focuses on electromechanical energy conversion, machine modeling, and the underlying electromagnetic principles.

Pre-requisites

- The fundamental concepts of electricity and electromagnetism
- The basics of electrical circuit analysis
- Elementary mechanical principles

ELECTRICAL MACHINE MODELING AND NUMERICAL SIMULATION



ECTS
5 credits



Component
École Nationale
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et des
Télécommunications

In brief

- **Ametys Code:** M34HKSBV
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Electromagnetic modeling of machines	UE				
Numerical experiences	Matière				

Electromagnetic modeling of machines



Component

École Nationale
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Télécommunications

In brief

- **Ametys Code:** N7EE03B
- **Open to exchange students:** Yes

Presentation

Objectives

This course aims to provide the necessary understanding to develop basic models of rotating electrical machines. The various models obtained are used to describe the behaviour 'as seen from the terminals', with a view to simulating them using equivalent circuit diagrams or controlling them.

By listing the various simplifying assumptions for linear modelling, learners will become familiar with key concepts such as periodicity, the concepts of smooth or salient poles, magnetic saturation and slot effects – all distinguishing characteristics that have a significant impact on the performance and accuracy of the models.

Description

By the end of the course, students will be able to:

1. Distinguish between the different classes of rotating magnetic machines: synchronous and asynchronous machines, and machines with smooth poles and salient poles
2. Apply modelling methods aimed at ultimately obtaining a simple steady-state or transient model (Behn-Eschenburg model, Blondel diagram, Steinmetz model, etc.)
3. Establish the basic analytical relationships to define a control model (Park, Clarke and Concordia transforms)

4. Calculate steady-state operating points, define the machine's operating regions in the torque-speed plane, and calculate short-circuit currents and efficiency
-

Pre-requisites

- The fundamentals of electricity and electromagnetism
- The basics of electrical circuit analysis
- The principles of electrical machines

Numerical experiences



Component

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Télécommunications

In brief

- **Ametys Code:** M34HKSGV
- **Open to exchange students:** Yes

Presentation

Objectives

Learn how to use low-frequency and high-frequency calculation software.

Be aware of the limitations of these tools (meshing/calculation time).

Critically analyze the results obtained in relation to theory or bibliographic references.

Description

This course is divided into two parts: one focused on low-frequency (LF) simulation and one on high-frequency (HF) simulation.

Students will be asked to use different tools (LF and HF) to simulate an electrical machine and an electronic function (antenna, filter, etc.). They will analyze the results obtained in relation to their theoretical calculations or results from publications.

Semestre 7 - Energy (NRJ)



ECTS
30 credits



Component
École Nationale
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d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M8FQ73FU
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
COMPUTER SYSTEMS ARCHITECTURE AND DEVELOPMENT	UE				5 credits
Object-oriented design and programming	UE				
Principles of Operating Systems	UE				
Computer Architecture	UE				
STATIC CONVERTER SYNTHESIS AND DESIGN	UE				5 credits
Energy approaches to the design of static converters	UE				
Static Converter Design Project	UE				
ELECTRICAL MACHINES	UE				5 credits
Electromagnetic modeling of machines	UE				
Principle and structure of machines	Module				
ELECTRICAL NETWORKS	UE				5 credits
Energy of today and tomorrow	UE				
Electrical energy technology	UE				
Electrical energy transmission network	UE				
Modulation and filtering of voltage inverters	UE				
LINEAR SYSTEMS CONTROL	UE				5 credits
Identification	UE				
Sampled systems	UE				
Synthesis of correctors and control architectures	UE				
Automatic Tutorials	UE				
SOFT AND HUMAN SKILLS	UE				5 credits
Professional English 2.1 : Presentations	Matière				
2nd language	Bloc				
Spanish	Matière				
Spanish	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
French as a Foreign Language	Matière				
LSF - S7	Matière				
Sports	Matière				
Leadership & Management	Matière				

COMPUTER SYSTEMS ARCHITECTURE AND DEVELOPMENT



ECTS
5 credits



Component
École Nationale
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d'Électronique
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et des
Télécommunications

In brief

- **Ametys Code:** N7EE01
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Object-oriented design and programming	UE				
Principles of Operating Systems	UE				
Computer Architecture	UE				

Object-oriented design and programming



Component

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In brief

- **Ametys Code:** N7EE01A
- **Open to exchange students:** Yes

Presentation

Objectives

The objective of the course is to provide an introduction to the principles of object-oriented design and programming. OO design is illustrated using the UML model, and programming focuses on the C++ language.

Description

The course includes a number of sections on modeling a computer system in the form of communicating objects.

We begin by addressing the basic concepts of this modeling (uniqueness, abstraction, classification, and reuse). After a quick review of the characteristics of imperative programming languages, we introduce the algorithmic characteristics of C++, before developing in detail the concepts of classification, dynamic object management, input/output processing, and templates.

A design office asks students to analyze a set of specifications, model the solution (UML, class diagram), and develop it in C++, including validation of the result. This design office is accompanied by a development report and delivery of the developed code.

Pre-requisites

A good knowledge of algorithms and C programming is absolutely necessary.

Principles of Operating Systems



Component

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Télécommunications

In brief

- **Ametys Code:** N7EE01B
- **Open to exchange students:** Yes

Presentation

Objectives

The objective of the course is to provide an introduction to the basic concepts, organization, and fundamental services of an operating system. The focus is on describing the basic services of an operating system kernel with the aim of discovering and practicing reactive and parallel multitasking programming.

Description

The course includes a number of sections on the organization of an operating system, the concept of processes/tasks, memory management, task scheduling, and system programming covering event synchronization, multithreaded programming, data sharing, and synchronization using semaphores and monitors.

This course includes examples and practice of these concepts on Unix-Linux in a design office environment. This course is accompanied by examples and practical application of these concepts on Unix-Linux in the context of design offices.

Three design offices offer students the opportunity to discover (1) the Shell and basic Unix/Linux commands, (2) the implementation of multiprocess and reactive applications (software signals), and (3) the implementation of multithreaded applications using semaphore synchronization mechanisms.

Pre-requisites

A good knowledge of algorithms and C programming is absolutely necessary

Computer Architecture



Component

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d'Hydraulique
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Télécommunications

In brief

- **Ametys Code:** N7EE01C
- **Open to exchange students:** Yes

Presentation

Objectives

- Analyze autonomous robotics specifications
- Analyze and develop a minimal microprocessor architecture
- Develop computer programs using interrupts
- Develop programs for testing and validating hardware interface operation
- Analyze and implement sensors and microprocessor interfaces

STATIC CONVERTER SYNTHESIS AND DESIGN



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7EE02
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Energy approaches to the design of static converters	UE				
Static Converter Design Project	UE				

Energy approaches to the design of static converters



Component

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Télécommunications

In brief

- **Ametys Code:** N7EE02A
- **Open to exchange students:** Yes

Presentation

Objectives

- Know how to identify the properties, as an instantaneous source (of voltage or current), of the different parts of an electrical diagram;
- Know how to construct or identify switching cells on an electrical diagram;
- Know how to identify, at different time scales, the degrees of freedom that these cells provide for controlling power transfers;
- Know how to express the mathematical transformation relationships performed on the electrical quantities of the cell;
- Know the different equivalent circuits of the cell;
- Know how to size the semiconductor components of the cell;
- Know how to construct the static and dynamic characteristics of the cell's semiconductors;
- Know how to synthesize the cell's power semiconductor components.

Description

This course is the first step and the basis for learning static converter design methods. It consists of a series of lectures (6) combined with tutorials (3) to consolidate the acquisition of skills. It is complemented in the same course unit by the “converter design” project.

Pre-requisites

Traditional methods for studying electrical circuits: Kirchhoff's laws, Thévenin or Millman equivalent circuits;

Electrical properties of reactive components (inductance, capacitor);

Concept of electrical sources (voltage, current);

Basic properties of semiconductors operating in switching mode (diodes, transistors, thyristors).

Static Converter Design Project



Component

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Télécommunications

In brief

- **Ametys Code:** N7EE02B
- **Open to exchange students:** Yes

Presentation

Objectives

Distinguish between degrees of freedom for directly controlling power transfer and those for improving electrical energy quality or efficiency (these two criteria are often conflicting).

Description

For the main basic converter topologies (AC-DC, DC-DC, DC-AC), this will involve:

- 1- Implementing power transfer in converters,
 - 2- Evaluating waveform quality and sizing input and output filters,
 - 2- Quantitatively evaluating losses in power converters.
-

Pre-requisites

Principles of operation of basic topologies (AC-DC, DC-DC, DC-AC)

(Typically: N6EE04D, N6EE06B, N7EE02A)

ELECTRICAL MACHINES



ECTS
5 credits



Component
École Nationale
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d'Électronique
d'Informatique
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et des
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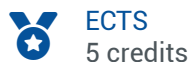
In brief

- **Ametys Code:** N7EE03
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Electromagnetic modeling of machines	UE				
Principle and structure of machines	Module				

ELECTRICAL NETWORKS



In brief

- **Ametys Code:** N7EE04
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Energy of today and tomorrow	UE				
Electrical energy technology	UE				
Electrical energy transmission network	UE				
Modulation and filtering of voltage inverters	UE				

Energy of today and tomorrow



Component

École Nationale
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Télécommunications

In brief

- **Ametys Code:** N7EE04A
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the order of magnitude of electricity consumption in an average household and in France. Compare these figures to the amount of power produced by a human being.

Estimate the surface area of PV required for production and the volume of hydraulic storage required to meet France's electricity consumption needs for two extreme scenarios (high and low consumption).

Description

Working with a design office, students study France's electricity consumption profile. They calculate power balances to ensure 100% PV production and set up hydraulic energy storage (pumped storage power station) to compensate for intermittent production. Small-scale experiments allow students to learn about the orders of magnitude of PV production (relative to surface area) and compare it with what a human being can produce.

Pre-requisites

Concepts of energy and power and the relationships between these quantities.

Basic concepts of electrical circuits and calculations of electrical power

Electrical energy technology



Component

École Nationale
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d'Électronique
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Télécommunications

In brief

- **Ametys Code:** N7EE04B
- **Open to exchange students:** Yes

Presentation

Objectives

Study the technology of electricity generation, transmission, and distribution networks. Size the components of a high-voltage network and a low-voltage network through case studies.

Description

Electricity generation: Electromechanical technology used, unit and available power, average start-up time, hydroelectric generation: hydraulic turbine technologies used, thermal generation, nuclear thermal generation, overview and functional diagram.

Transmission network: overview and functional diagram, substation technology, functions, line technology, insulation, overhead and underground cable technology.

Distribution network: overview and functional diagram, substation, feeder technology, (external) technology of HV-LV transformers and LV lines.

Pre-requisites

General relationships in single-phase and three-phase electrical engineering

Electrical energy transmission network



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7EE04C
- **Open to exchange students:** Yes

Presentation

Objectives

Acquire basic knowledge of alternating current electrical power transmission networks

Description

This course presents the operating principles of alternating current electrical power transmission networks and the modeling of the components of these networks. It covers the following topics:

- Architecture of a meshed electricity transmission and distribution network.
- Modeling of network components: generators, transformers, lines
- Voltage and reactive power control
- Frequency control.
- Calculation of an asymmetrical fault current using the symmetrical components method.

Pre-requisites

Basic knowledge of electrical circuits operating in sinusoidal alternating current mode. Understanding of three-phase electrical circuits

Modulation and filtering of voltage inverters



Component

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Télécommunications

In brief

- **Ametys Code:** N7EE04D
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the principles of modulation and filtering in single-phase or three-phase PWM voltage inverters

Description

This course begins by presenting the basic principles of pulse width modulation control in single-phase or three-phase voltage inverters. Different waveforms are analyzed in order to determine the voltage and current filtering elements. Examples are covered in the form of tutorials and design office exercises.

Pre-requisites

Knowledge of the basic structures of static electrical energy conversion.

- Knowledge of second-order filters.

- Basic knowledge of spectral analysis

LINEAR SYSTEMS CONTROL



ECTS
5 credits



Component
École Nationale
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et des
Télécommunications

In brief

- **Ametys Code:** N7EE05
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Identification	UE				
Sampled systems	UE				
Synthesis of correctors and control architectures	UE				
Automatic Tutorials	UE				

Identification



Component

École Nationale
Supérieure
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et des
Télécommunications

In brief

- **Ametys Code:** N7EE05A
- **Open to exchange students:** Yes

Presentation

Objectives

The aim of this course is to understand the general methodology of identification and to discover the Fort Signal method (for rapid characterization), the Least Squares method (for linear systems), and the iterative method (for nonlinear systems).

Description

Parametric identification is a set of tools that enable the characterization of a system based on experimental knowledge of its inputs and outputs. The goal is to obtain a mathematical model describing the overall behavior of the system.

Pre-requisites

Signal and control

Sampled systems



Component

École Nationale
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Télécommunications

In brief

- **Ametys Code:** N7EE05B
- **Open to exchange students:** Yes

Presentation

Objectives

- Fourier series decomposition,
 - SLC1, SLC2, and SLC3 courses: plotting Bode, Black, and Nyquist diagrams, calculating continuous linear correctors, nested loops, and feedforward chains,
 - elementary calculations with the Z transform, signal transform, inverse transform, final value theorem, initial value theorem, delay theorem, etc.
 - calculations with complex numbers,
- solving first- and second-order differential equations.

Description

Presentation of a sampled speed control system: block diagram, functions implemented in a numerical control system.

Influence of the sampling period: influence of the sampling period on stability, destabilizing effect of sampling/blocking.

Study of control by approximation to a continuous system: definition of the equivalent continuous system, methods for studying sampled control systems, synthesis of the p-corrector, discretization of the continuous corrector.

Z-transform: definition and properties, discrete transfer functions, real poles-complex poles.

Temporal study of sampled servo systems: static study: accuracy, dynamic study: stability, temporal responses.

Criteria for choosing the sampling period: Shannon criterion, real poles, complex poles, phase shift due to sampling/blocking, processing time on the computer, derivation problem, influence of noise, number encoding on the microprocessor.

Experimental adjustment of sampled correctors

Synthesis of correctors and control architectures



Component

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et des
Télécommunications

In brief

- **Ametys Code:** N7EE05C
- **Open to exchange students:** Yes

Presentation

Objectives

Be able to...

- Choose a type of controller suited to a set of specifications,
- Simplify models and determine their validity range,
- Calculate the parameters of a P, PI, phase advance, or PID controller using different methods,
- Choose the method based on the context and specifications,

Description

Scenario: support application

Advantages of closed-loop control: open-loop, closed-loop, proportional correction, stability, accuracy, speed = a cruel dilemma!, calculation of proportional controller/specifications

Integral controllers: dominant pole compensation method, symmetrical optimum method, 1/10 method, implementation

Derivative controllers: calculation of parameters by imposing bandwidth, by the pole compensation method, implementation

PID controllers: calculation by pole compensation, by PI combination – Phase advance

Experimental methods for adjusting PI and PID controllers: Expert adjustment, Broïda method, Ziegler Nichols method, and relay method

Control architectures: PI and more... More state variables to control; a little anticipation

Conclusion: comparisons, summary and outlook

Pre-requisites

Basic calculations with Laplace transforms: signal transforms, inverse transforms, final value theorems, initial value theorems, delay theorems, etc.

Calculations with complex numbers.

Solving first- and second-order differential equations.

Proficiency with Bode and Nyquist diagrams.

Automatic Tutorials



Component

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Télécommunications

In brief

- **Ametys Code:** N7EE05D
- **Open to exchange students:** Yes

Presentation

Objectives

Be able to

solve practical problems involving linear, continuous, or discrete control, through simulation or experimentation

identify the parameters that have the greatest influence on a system

analyze performance and deviations from theory or predetermined values

Description

I Position Control

Study of several continuous correction structures (in p), performance and robustness analysis

II Study of control structures (double PI or PID)

III Identification and position control of a motorized butterfly valve

IV Study of Sampled Systems

GUI – Matlab/Simulink – Analysis and Discrete Correctors (in z)

Pre-requisites

Closed-loop system analysis methods

Continuous or discrete PID controller synthesis methods

Influence of the sampling period

Strong signal identification methods

Semestre 8 - Systems Integration (INSYS)



ECTS
30 credits



Component
École Nationale
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et des
Télécommunications

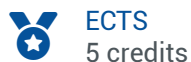
In brief

- **Ametys Code:** M8FPOUH7
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
FROM SILICON TO INTEGRATED CIRCUIT	UE				5 credits
From Silicon to Integrated Circuits	UE				
MICROWAVES	UE				5 credits
HFSS	UE				
Antennas Project	UE				
Microwave Project	UE				
Microwave Tutorials	Matière				
DIGITAL SYSTEMS ARCHITECTURE	UE				5 credits
Synchronous design of digital systems	Matière				
FPGA technology	UE				
Verification	EC				
CIRCUITS AND OPTOELECTRONICS	UE				5 credits
Analog integrated circuits	UE				
Optoelectronics	UE				
Optoelectronics Tutorials	Matière				
NANOSATELLITE SYSTEMS	UE				5 credits
Cubesat platform: an introduction	Matière				
Payload Sizing	Matière				
SOFT AND HUMAN SKILLS	UE				5 credits
Professional English 2.2 : Debates	Matière				
Second language	Choix				
Spanish	Matière				
Spanish	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
french (as a foreign language)	Matière				
LSF - S8	Matière				
Sports	Matière				
Careers and Management - Sem.8	Choix				
Leadership	Matière				
Entrepreneurship	Matière				
Citizenship	Matière				
Managership-S8	Matière				

FROM SILICON TO INTEGRATED CIRCUIT



In brief

- **Ametys Code:** N8EE12
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
From Silicon to Integrated Circuits	UE				

From Silicon to Integrated Circuits



Component

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In brief

- **Ametys Code:** N8EE12A
- **Open to exchange students:** Yes

Presentation

Objectives

Design, manufacture, and characterize a two-stage CMOS operational amplifier using 0.6 μm technology.

Description

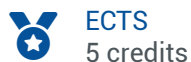
The objective of this training course is to offer a comprehensive module covering everything from modeling 6 μm CMOS technology to testing an analog circuit manufactured in a clean room, following a design and simulation phase. Using project-based learning (PBL) methods and active teaching techniques, this training course promotes learning about CMOS circuit design tools and methods through the design and practical implementation of a two-stage CMOS amplifier that meets specific specifications. Throughout this 10-day project, students organized into groups of four will analyze and compare their measurement results with their theoretical and simulated studies for both the technological aspects (characterization of MOS capacitances, diodes, MOS transistors) and the circuit aspects (bandwidth, gain, slew rate, offset, consumption, input and output range).

Pre-requisites

Transistor amplifier circuits

Semiconductor physics and PN junctions

MICROWAVES



In brief

- **Ametys Code:** M34HLQ8I
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
HFSS	UE				
Antennas Project	UE				
Microwave Project	UE				
Microwave Tutorials	Matière				

HFSS



Component

École Nationale
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Télécommunications

In brief

- **Ametys Code:** N8EE02A
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of this course, students will be able to use HFSS to perform simple electromagnetic simulations of microwave circuits (propagation lines, filters, antennas) in waveguide and planar technology.

Antennas Project



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8EE02B
- **Open to exchange students:** Yes

Presentation

Objectives

By the end of this course, students will:

- be familiar with the different types of antennas and their radiation principles,
- be familiar with the different fundamental parameters that characterize antennas,
- know how to study a link budget between two antennas (transmission and reception) (Friis formula),
- be able to size an antenna array (linear or planar) for a given set of specifications,
- be familiar with certain antenna simulation tools and characterization methods (measurement),
- be able to analyze a scientific article.

Description

This project is a PBL (Project-Based Learning) project.

It consists of two parts (Course & BE):

A- Course

- Introduction to radiation,
- Different types of antennas,
- Fundamental parameters,
- Link budget,
- Introduction to antenna arrays,
- Simulation tools and characterization methods (measurement),
- Introduction to the analysis of scientific articles.

B- Design office

- Analysis of a scientific article:
 - Ability to reproduce the design of an antenna presented in a scientific journal (article) and understand how it works,
 - Study the performance of this antenna in terms of adaptation and radiation.
- Reproduction of a "comparison & critical review" design:
 - Ability to reuse this antenna by meeting specific specifications (different frequency band, different technology, etc.)
 - Ability to adjust design parameters in order to modify performance.
- Networking of an elementary antenna:
 - Ability to network an elementary antenna (1D linear and 2D planar) by setting the optimal inter-element distance (network mesh) for a given misalignment.
 - Parametric study: impact of inter-element distance and number of elementary antennas (1D and 2D) on radiation performance (directivity, gain, array lobes, secondary lobes SLL, power and aperture efficiency, etc.).
- Drafting of a technical data sheet (design report)

Pre-requisites

Electromagnetism

Materials physics (dielectric materials section)

Propagation in lines

Transmission lines

Microwave Project



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8EE04A
- **Open to exchange students:** Yes

Presentation

Objectives

Upon completion of this course, students will be able to:

- Work in a cooperative environment with different design teams.
- Define equipment specifications that enable system specifications to be met.
- Define the topology of equipment that meets the following criteria:
 - gain (losses), linearity, consumption, power dissipation, efficiency and performance.
- Define appropriate design methods.
- Implement a function using planar technology.
- Comply with electrical performance constraints, technology implementation constraints and design deadlines.
- Characterise equipment through simulation and measurement

Analyse equipment performance

Propose methods for correcting devices in order to strictly meet the initial specifications.

Description

Design of an RF Rx/TX system using planar technology: 6GHz to 4GHz transponder.

Students are responsible for developing equipment that will be integrated into the overall system. All functions will be developed entirely from the definition of specifications to their physical realization and characterization.

The various pieces of equipment produced are:

- Antennas
- Preselection filters
- IF filters
- Image filters
- Amplifiers: LNA, LLA, MLA
- Mixers
- Oscillators
- Duplexer

Pre-requisites

Course N7EE09B "Passive RF Circuits" - 2nd year EEEA, Electronics track

Course N9EE06A "Active RF Circuits" - 2nd year EEEA, Electronics track

ADS lab, N7EE06D, 2nd year EEEA, Electronics track

Microwave Tutorials



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HLAHB
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of this series of practical sessions, students will be able to characterise microwave components using dedicated measuring equipment.

Description

- Different topologies of couplers, power dividers and filters are measured using vector network analysers.
- Spectral analysis is used to characterise frequency conversion performed using an oscillator and a mixer, as well as the non-linearity of power amplifiers. Noise factor measurements are also performed.
- The radiation pattern of an antenna is determined using a wattmeter.

Pre-requisites

- S parameters

- Passive and active RF circuits
- Antennas

DIGITAL SYSTEMS ARCHITECTURE



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8EE03
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Synchronous design of digital systems	Matière				
FPGA technology	UE				
Verification	EC				

Synchronous design of digital systems



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8EE03E
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand the usefulness of synchronous digital circuits compared to asynchronous circuits (predictability, robustness against jitter and random events).
- Know and implement synchronous circuit design techniques.
- Know how to determine the essential parameters of such a circuit in order to understand its limitations (particularly time parameters).
- Be able to choose a circuit architecture to meet a constraint (operating frequency, size, power consumption).
- Design, on paper and in VHDL, state machines to describe the behaviour of digital circuits.

Description

The course consists of 5 hours and 15 minutes of lectures and 17 hours and 30 minutes of project work. It is assessed by means of a project report and the validation of milestones during the project sessions.

The lectures present the concepts described in the objectives from a theoretical perspective.

The project allows students to put these concepts into practice by designing a digital system in VHDL that uses a thermometer. Students must study the thermometer's datasheet to develop state machines that can communicate with this component.

Pre-requisites

- Knowledge of combinational and sequential electronics.
- Knowledge of low-level FPGA architecture as covered in the FPGA Technology course (N8EE03C)
- Proficiency in VHDL

FPGA technology



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8EE03C
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the differences between an ASIC and an FPGA.

Describe and use the specialised computing resources available on an FPGA.

Perform the synthesis and implementation process for simple arithmetic operations on the computing structures available on an FPGA.

Description

This course provides a detailed definition of the FPGA (Field Programmable Gate Array) family of components. First, the advantages of these components over ASICs are described. Then, the various resources (basic and advanced) available in an FPGA are detailed. Finally, the operation of synthesis tools is explained through a few simple examples.

Pre-requisites

Logic system design (UE N5EE03)

Digital electronics (UE N7EE08)

Synchronous design of digital systems (N8EE03A)

Verification



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** ELP7
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand the challenges of digital circuit verification (reliability requirements coupled with increasing circuit complexity).
- Understand and implement digital electronic circuit verification techniques in projects (assertions, code coverage, formal verification, etc.).
- Know how to identify the limitations of verification.

Description

The course comprises 3.5 hours of lectures and 10.5 hours of project work, and is assessed through a project report.

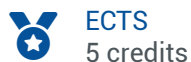
The lectures present the concepts described in the learning objectives from a theoretical perspective.

The project allows students to put these concepts into practice by verifying an electronic circuit in which errors were intentionally introduced during the design phase.

Pre-requisites

- Proficiency in VHDL
- Experience in the design of synchronous digital systems.

CIRCUITS AND OPTOELECTRONICS



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HLRKR
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Analog integrated circuits	UE				
Optoelectronics	UE				
Optoelectronics Tutorials	Matière				

Analog integrated circuits



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8EE02C
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the basic structures of integrated electronics in bipolar and MOS transistors.

Design amplification, filtering and analogue processing chains.

Understand the principle of amplifier compensation using the Miller effect.

Design an amplifier in accordance with specifications.

Description

This course covers three areas: (1) fundamental functions performed using MOS and bipolar transistors; (2) the principle of negative feedback, different topologies and their effects on gain, input and output impedance, and bandwidth; and (3) the Miller effect-based compensation method for amplifiers.

Practical application will be carried out through the analysis of the 741 op-amp (theory and simulation) and the design of a CMOS amplifier (theory, simulation).

Pre-requisites

- Circuit basics
- Operational amplifiers and compensation
- Semiconductor physics and PN junctions
- Signal transistors and power components
- Transistor amplifier circuits

Optoelectronics



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8EE04B
- **Open to exchange students:** Yes

Presentation

Objectives

By the end of this course, students will be able to:

- Understand the fundamental principles of optical fiber communications and the physical properties of optical fibers (attenuation, bandwidth).
- Describe the operation and characteristics of light sources (PN junction LEDs, laser diodes) and photodetectors (photodiodes).
- Design and analyze amplification and filtering circuits for optical receivers, considering noise and bandwidth constraints.
- Evaluate the impact of noise in photodetection and propose solutions to optimize signal-to-noise ratio (SNR).
- Apply theoretical knowledge to practical scenarios in fiber optic communication systems.

Description

This course provides an introduction to optoelectronics, focusing on fiber optic communication systems. The main topics covered include:

- **Optical Fiber Fundamentals:** Types of optical fibers, attenuation mechanisms, dispersion, and bandwidth limitations.

- **Light Sources:** Operation and characteristics of PN junction-based light sources (LEDs and laser diodes), including modulation and efficiency.
- **Photodetectors:** Principles of photodiodes (PIN, APD), responsivity, and noise mechanisms.
- **Amplification and Filtering Electronics:** Design of transimpedance amplifiers (TIAs), noise analysis, and filtering techniques for optical receivers.
- **Noise in Photodetection:** Sources of noise (shot noise, thermal noise, dark current), and strategies to minimize their impact on system performance.
- **System-Level Considerations:** Integration of components into fiber optic communication links, including budget calculations and performance optimization.

The course combines theoretical lectures, practical exercises, and laboratory sessions to reinforce concepts and develop hands-on skills.

Pre-requisites

- Basic knowledge of semiconductor physics and PN junctions.
- Familiarity with analog electronics (amplifiers, filters, and noise analysis).
- Understanding of fundamental communication principles (modulation, signal transmission).

Optoelectronics Tutorials



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HL8HY
- **Open to exchange students:** Yes

Presentation

Objectives

The main objective is to enable students to put into practice the concepts covered in the Optoelectronics course in order to better understand the various concepts in optical telecommunications and optical metrology, such as losses and attenuation in fibre components, bandwidth of fibre optic communication systems, and even optical interferometry for measuring physical quantities through five practical sessions. These experiments have been designed to enable students to better understand and master the fundamental topics covered in the second-year Optoelectronics course in the INSyS and SysCom programmes, and to equip them for success in the fields of optical telecommunications and optical metrology.

Description

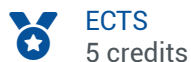
This series of Optoelectronics practicals comprises five experiments covering various topics in optical telecommunications and optical metrology. In Opto 1, students characterise optical losses in fibre components (such as long fibres, isolators, optical attenuators, etc.) used in optical telecommunications. In Opto 2, they characterise the time of flight and chromatic dispersion in optical fibres, two fundamental concepts in optical fibre propagation. In Opto 3, students also manipulate light sources (LEDs and laser diodes) to characterise their response and radiation profile. In Opto 4 lab work, students will use a fibre optic interferometer to

measure the displacement of a target or object with sub-micrometric resolution in the context of precision optical metrology. Finally, in Opto 5 lab work, students will estimate the bandwidth of an optical telecommunications link based on different optical fibres.

Pre-requisites

Have attended the second-year Optoelectronics course at ENSEEIHT, be able to use and handle the various equipment and instruments seen in practical work (oscilloscope, spectrum analyser, function generator, photodetector, etc.), understand the principles of optical calculation, be able to analyse the results of measurements taken in Optoelectronics practical work sessions.

NANOSATELLITE SYSTEMS



In brief

- **Ametys Code:** M34HL9MN
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Cubesat platform: an introduction	Matière				
Payload Sizing	Matière				

Cubesat platform: an introduction



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HL9UW
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the various system constraints of the CubeSat platform.

Conduct a Phase A analysis of a satellite mission using a dedicated mission analysis tool.

Understand the various components involved in controlling the satellite's attitude and maintaining its orbit: SCAO system.

Implement satellite attitude control according to mission requirements.

Description

Lectures:

- A. Dufour – CNES: Radiation and components
- N. Verdier – CNES: the CubeSat programmes Nanolab Academy
- J.L. Le Gal – CNES: Introduction to space mechanics
- J.L. Le Gal – CNES: CNES concurrent engineering tools
- CM: Attitude and orbit control system (SCAO)

Description of the different satellite modes (detumbling, pointing, tracking, end of life)

Description of actuators: gyroscope, magnetocouplers

Description of nanosatellite architecture (platform, payload, mechanical components)

Concepts of space mechanics:

Orbits

Coordinate systems: equatorial, ecliptic, geocentric, terrestrial, orbital, satellite, instrument

Satellite attitude representation:

MCD matrix, Euler angles, quaternion

Satellite attitude: kinematic and dynamic models, disturbing torques

Attitude simulator: digital twin

Actuator modelling

PID controllers

Control law based on quaternion description

CubeSat project:

Use of CNES concurrent analysis tools:

IDM-CIC: construction of a digital twin, data extraction (mass, inertia, consumption

Simu-CIC, IDM-View, VTS, STELA: Choice of orbit according to mission requirements (illumination vs. consumption, orbital lifetime, satellite attitude for mission completion, ground station visibility time, data volume)

Development of an in-orbit attitude propagator using Simulink

Implementation of an attitude control mode using MTQ and reaction wheels: detumbling, ground pointing

Payload Sizing



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HL9QI
- **Open to exchange students:** Yes

Presentation

Objectives

- Design a satellite architecture to meet mission requirements. Illustration using a case study from a Thales Alenia Space mission.
- Understand requirements in terms of data throughput, modulation schemes, information encoding, frequency band and frequency transposition.
- Describe the various satellite equipment and their functional constraints.
- Establish the various ground-to-space link budgets within the satellite: NF, power, C/I, C/I3.
- Design ground and on-board antenna requirements (concept of PIRE). Presentation of the various satellite antenna topologies.

Description

Lecture (M.F. Foulon – Thales Alenia Space): Description of the METOP 5G mission and sizing of the satellite system architecture based on satellite requirements analysis.

BE sizing:

- Extract the linearity characteristics of equipment (TWTA) from measured data (IP3, C/I, Psat, OBO, IBO, PAE, AM/AM characteristics, AM/PM characteristics, consumption, dissipation).

- Establish a non-linear equipment simulation model based on the extracted data.
- Understand the effects of noise and non-linearities on system performance.
- Design a frequency conversion chain architecture according to two distinct operating modes: FGM (Fixed Gain Mode) and ALC (Automatic Level Control)

Pre-requisites

N7EE06A - Active RF Circuits

N7EE06C – Advanced Design System Practical Work

SOFT AND HUMAN SKILLS



ECTS

 5 credits



Component

 École Nationale

 Supérieure

 d'Électrotechnique

 d'Électronique

In brief

- > **Ametys Code:** N8EK01
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Professional English 2.2 : Debates	Matière				
Second language	Choix				
Spanish	Matière				
Spanish	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
french (as a foreign language)	Matière				
LSF - S8	Matière				
Sports	Matière				
Careers and Management - Sem.8	Choix				
Leadership	Matière				
Entrepreneurship	Matière				
Citizenship	Matière				
Managership-S8	Matière				

Professional English 2.2 : Debates



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **plugin.odf-inp:PLUGINS_ODF_COURSE_NBHOURS_TXT:** 21
- **Ametys Code:** N8EK01A

Presentation

Objectives

Perform key oral and written workplace tasks in English.

Description

A semester of 12 interactive weekly sessions to develop English intercultural communication competencies for professional purposes.

Pre-requisites

None

Second language



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N8EK01B
- **Open to exchange students:** No

Presentation

Description

Develop professional communication skills by performing common written and oral communication tasks in foreign languages other than English.

List of courses

	Nature	CM	TD	TP	Crédits
Spanish	Matière				
Spanish	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
french (as a foreign language)	Matière				
LSF - S8	Matière				

Spanish



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N8EK01BA

Spanish



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N8EK01BB

Chinese



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N8EK01BC

Italian



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N8EK01BD

Japanese



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N8EK01BE

Russian



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N8EK01BF

German



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N8EK01BG

french (as a foreign language)



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N8EK01BH

LSF - S8



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M4R9V0GX

Sports



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N8EK01C
- **Open to exchange students:** No

Presentation

Description

Physical education and sports courses are spread over four semesters and include a maximum of 80 hours of classroom training. They are organized by the INP's Department of Physical Education and Sports (Département d'Éducation Physique et Sportive, DEPS-INP), which also offers participation in numerous university tournaments and events. There is a dynamic student sports association that offers a wide range of activities throughout the academic year.

Careers and Management - Sem.8



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

> **Ametys Code:** M4R9V5XT

List of courses

	Nature	CM	TD	TP	Crédits
Leadership	Matière				
Entrepreneurship	Matière				
Citizenship	Matière				
Managership-S8	Matière				

Leadership



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** M4R9V63Z
- **Open to exchange students:** No

Presentation

Objectives

M1 Leadership 1: Project Management

1. Understand the principles of project management.
2. Develop skills in project planning and execution.
3. Analyze and compare project management approaches.
4. Apply project management techniques in case studies.
5. Facilitate effective meetings with project clients and stakeholders.
6. Use tools for project planning and communication.

M1 Leadership 1: Conflict Management

1. Understand the root causes of conflict in the workplace.
2. Develop negotiation skills.
3. Analyze and compare conflict management approaches.
4. Apply different techniques to resolve conflicts with colleagues.

M1 Leadership 2 : Business Game in Managerial Accounting

1. Decode and analyze summary accounting documents
2. Understand how to interpret commercial study documents (market shares, seasonal coefficients)

3. Calculate costs and margins, develop production plans, commercial forecasts, and profitability projections, considering mainly commercial strategic choices
4. Organize themselves in groups, follow instructions, and apply negotiation techniques.

Description

M1 Leadership 1: Project Management

By the end of the module, students will have :

- # effectively planned and executed projects using traditional methods, focusing on aspects such as Gantt charts, critical path analysis, and resource allocation.
- # analyzed and compared basic project management approaches with other methodologies, particularly understanding the context in which project management is most effective.
- # applied basic project management techniques to real-world or simulated case studies.
- # efficiently conducted and facilitated meetings with project clients and stakeholders, focusing on techniques to maximize time and cost efficiency.

M1 Leadership 1: Conflict Management

Session 1: Introduction to conflict management

Session 2: Process Communication Management

Session 3: Negotiations

Session 4: Conflicts across cultures 1

Session 5: Conflicts across cultures 2

Session 6: Role Plays

M1 Leadership 2 : Business Game in Managerial Accounting

By the end of the module, students will have :

- # familiarized themselves with a number of key business concepts (recruitment/HR, management/finance, marketing/communication, etc.);
- # worked as team players and leaders to make complex strategic business decisions respecting constraints, deadlines, objectives, etc.;
- # measured the impact of their decisions on company performance.

Entrepreneurship



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M4R9V6A1

Citizenship



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M4R9V6FO

Managership-S8



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M4R9V6M7

Semestre 8 -Communication Systems (SYSCOM)



ECTS
30 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

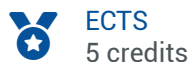
In brief

- **Ametys Code:** M8FP4ZUL
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
APPLIED MATHEMATICS	UE				5 credits
Advanced linear algebra	UE				
Hilbertian analysis	UE				
Optimisation under constraints	Matière				
PHYSICAL PHENOMENA AND MODELING	UE				5 credits
Electromagnetic radiation and antennas	Matière				
Physical analysis of guiding structures	UE				
Project: Modelling of structures in EM	Matière				
MICROWAVE DEVICES	UE				5 credits
Planar antennas and radiating apertures	UE				
Microwave Project	UE				
Microwave Tutorials	Matière				
SCIENTIFIC COMPUTING AND OPTOELECTRONICS	UE				5 credits
Finite elements for electromagnetism	Matière				
Programming for scientific computing	Matière				
Optoelectronics	UE				
Optoelectronics Tutorials	Matière				
NANOSATELLITE SYSTEMS	UE				5 credits
Cubesat platform: an introduction	Matière				
Payload Sizing	Matière				
SOFT AND HUMAN SKILLS	UE				5 credits
Professional English 2.2 : Debates	Matière				
Second language	Choix				
Spanish	Matière				
Spanish	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
french (as a foreign language)	Matière				
LSF - S8	Matière				
Sports	Matière				
Careers and Management - Sem.8	Choix				
Leadership	Matière				
Entrepreneurship	Matière				
Citizenship	Matière				
Managership-S8	Matière				

APPLIED MATHEMATICS



 **Component**
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8EE22
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Advanced linear algebra	UE				
Hilbertian analysis	UE				
Optimisation under constraints	Matière				

Advanced linear algebra



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8EE06B
- **Open to exchange students:** Yes

Presentation

Objectives

To supplement the fundamentals of linear algebra for solving problems arising from signal processing or numerical modelling.

Description

The following topics will be covered

- * Eigenvalue/singular value decomposition:
 - definition, existence, characterisation.
 - Low-rank approximation and link to PCA.
 - Some elements of perturbation theory (related to data uncertainty and finite arithmetic calculation).
 - Main numerical methods for calculating eigenpairs (QR, iterative power and subspace methods, Lanczos/Arnoldi method).
- * Solving systems of linear equations

- characterisation of solutions: inverse, least squares and pseudo-inverse
- some elements of perturbation theory - link with conditioning and finite arithmetic
- main numerical methods for solving linear systems (based on factorisation or iterative methods) fixed point and nested subspace methods
- convergence acceleration principle (preconditioning)

Pre-requisites

basic knowledge of vector spaces and matrix calculus.

Hilbertian analysis



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
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In brief

- **Ametys Code:** N8EE06C
- **Open to exchange students:** Yes

Presentation

Objectives

Introduction to the fundamentals of Hilbert space theory, in order to be able to solve certain PDE problems.

Description

This course will introduce the definitions and properties of Hilbert spaces, the concepts of scalar product and orthogonality, the theorems of orthogonal projection onto a closed convex set or onto a closed subspace, as well as the basic concepts of Hilbert spaces. In application, we will use the spectral decomposition of operators to approximate solutions to typical partial differential equation problems.

Pre-requisites

Lebesgue integral, L^p spaces, Fourier analysis, linear algebra, optimisation

Optimisation under constraints



Component

École Nationale
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In brief

- **Ametys Code:** M34HL4UJ
- **Open to exchange students:** Yes

Presentation

Objectives

The aim of the course is to understand how to formulate and analyse an optimisation problem involving equality or inequality constraints. It also aims to present the classical methods used to solve this type of problem numerically, in particular the SQP, interior point, active set and Uzawa approaches.

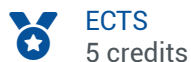
Description

This module introduces the fundamentals of continuous optimisation under constraints, starting with the Lagrange function and associated multipliers. The Karush–Kuhn–Tucker conditions are presented and interpreted intuitively to understand the role of active constraints and the nature of stationary points. The course then describes the main numerical methods used in practice, such as SQP-type approaches, interior point or active set algorithms, and the Uzawa method (first algorithm). Simple examples illustrate the differences in behaviour between algorithms and their sensitivity to the choice of initial point. The course also emphasises the use of MATLAB solvers, notably `fmincon`, in order to establish a direct link between theory and implementation.

Pre-requisites

A basic understanding of continuous optimisation is recommended (1A-ENSEEIH), in particular the concepts of gradient, Hessian, local convexity and descent methods. Basic skills in differential calculus and minimal experience with MATLAB or Python are desirable in order to understand the examples and experiment with the numerical methods presented.

PHYSICAL PHENOMENA AND MODELING



In brief

- **Ametys Code:** N8EE26
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Electromagnetic radiation and antennas	Matière				
Physical analysis of guiding structures	UE				
Project: Modelling of structures in EM	Matière				

Electromagnetic radiation and antennas



Component

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In brief

- **Ametys Code:** N8EE26A
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the physical origin of electromagnetic radiation – Know how to calculate and physically interpret the electromagnetic field radiated by a harmonic electrical current distribution

- Understand, know how to calculate and know how to manipulate the fundamental descriptors of antennas
- Understand the fundamental properties of wire antennas
- Know how to formulate and physically interpret link balances involving a transmitting antenna and a receiving antenna

Description

- I- Electromagnetic field radiated by a harmonic electrical current distribution
- II- Power radiated by a harmonic electrical current distribution
- III- Concept of electromagnetic radiation intensity
- IV- Fundamental descriptors of antennas
 - IV-1- Directivity (radiation pattern, main lobe, blind directions, 3dB opening angle, side lobe level, E and H planes)
 - IV-2- Input impedance
 - IV-3- Efficiency

IV-4- Gain
IV-5- Polarisation
IV-6- Effective area
IV-7- Bandwidth
IV-8- Phase centre
V- Link budget (Friis equation)
VI- Prospects in the field of antennas and related technologies

Pre-requisites

The subject 'Guided and free space propagation' (Apogée code N7EE09A1)

Physical analysis of guiding structures



Component

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Télécommunications

In brief

- **Ametys Code:** N8EE07E
- **Open to exchange students:** Yes

Presentation

Objectives

Know how to physically analyse the electromagnetic properties of guiding structures and cavities
Know how to calculate the power carried and the energy stored in guiding structures excited by electromagnetic field sources
Know how to establish and numerically solve the dispersion equation for any guided structures
Know how to establish and numerically solve the resonance equation for any cavities

Description

- I- Modal representation of the electromagnetic field
 - I-1- Orthonormal modal basis in guided structures
 - I-2- Modal representation of the electromagnetic field
- II- Symbolic representation of closure and transition relations in electromagnetism
 - II-1- Symbolic representation of closure relations
 - II-1-1- Dipole for the representation of an infinite half-guide
 - II-1-2- Dipole for representing a short-circuited half-wave guide
 - II-1-3- Quadrupole for representing a section of guide
 - II-1-4- Application: maximisation of the power delivered by a harmonic current source

in a waveguide

II-2- Symbolic representation of the transition relations imposed on the electromagnetic field when crossing a surface

II-2-1- Virtual electromagnetic field sources and their dual quantities

II-2-2- Quadrupole for representing any surface

III- Formulation of boundary value problems without real electromagnetic field sources

III-1- Equivalent diagram of guiding structures without real sources

III-1- Formulation of boundary value problems based on Kirchhoff's and Ohm's laws

IV- Solving boundary value problems without real electromagnetic field sources

IV-1- Galerkin method with a virtual source test function

IV-2- Application No. 1: dispersion equation of a microstrip line

IV-3- Application No. 2: dispersion equation of a ribbed guide

V- Prospects in the field of electromagnetic modelling of guided structures

Pre-requisites

The subject 'Guided and free space propagation' (Apogée code N7EE09A1)

Project: Modelling of structures in EM



Component

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In brief

- **Ametys Code:** N8EE07F
- **Open to exchange students:** Yes

Presentation

Objectives

Implementation of theoretical modelling skills and software skills in a given application. Each group has a different topic relating to line characterisation in terms of propagation (particularly dispersion equations).

Description

During this project, students must put into practice the skills they have acquired in electromagnetic modelling. This project consists of five sessions. The first three sessions are generally devoted to the analytical solution of the problem posed. The following two sessions allow students to program the equations obtained in MATLAB and compare the results with those obtained using 3D electromagnetic simulation software: Ansoft-HFSS. A critical and comparative analysis of the results obtained is expected.

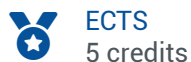
Pre-requisites

Electromagnetism course

Transmission line course

Physical analysis of guided structures course Use of Ansoft-HFSS and Matlab tools.

MICROWAVE DEVICES



In brief

- **Ametys Code:** M34HLADK
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Planar antennas and radiating apertures	UE				
Microwave Project	UE				
Microwave Tutorials	Matière				

Planar antennas and radiating apertures



Component

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In brief

- **Ametys Code:** N8EE08B
- **Open to exchange students:** Yes

Presentation

Objectives

Know how to calculate the electromagnetic field radiated by radiating apertures and planar antennas.

- Know how to physically interpret the radiation of a radiating aperture and a planar antenna.
- Know how to calculate the fundamental descriptors of radiating apertures and planar antennas.
- Understand the fundamental properties of radiating apertures and planar antennas.
- Understand the excitation techniques for radiating apertures and planar antennas.
- Know how to design a radiating aperture or planar antenna based on specifications.

Description

I- Radiating apertures

I-1- Duality of Maxwell's equations for electric and magnetic current sources

I-2- Electromagnetic field radiated by harmonic electric and magnetic current distributions

I-3- Integrals of electromagnetic radiation

I-4- Equivalence principles in electromagnetism (LOVE's equivalence principle)

I-5- Application: Rectangular radiating aperture

I-6- Common radiating apertures and their properties

II- Planar antennas

II-1- Operating principle

II-2- Choice of substrate and MMIC technology

II-3- Electromagnetic model of a planar antenna

II-4- Application: Rectangular planar antenna

II-5- Excitation of planar antennas

III- Prospects in the field of radiating apertures and planar antennas

Pre-requisites

The subject 'Electromagnetic radiation and antennas' (Apogée code N8EE26A)

SCIENTIFIC COMPUTING AND OPTOELECTRONICS



ECTS
5 credits



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In brief

- **Ametys Code:** M34HL81X
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Finite elements for electromagnetism	Matière				
Programming for scientific computing	Matière				
Optoelectronics	UE				
Optoelectronics Tutorials	Matière				

Finite elements for electromagnetism



Component

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In brief

- **Ametys Code:** N8EE22A
- **Open to exchange students:** Yes

Presentation

Objectives

Approximate solution of partial differential equations using the finite element method, applied to physical problems frequently encountered by electronic engineers.

Description

Finite element principles

Variational formulation

Basis functions and discretization

1D and 2D meshes

Solution.

Practical application using the Matlab PDE toolbox

electronics-related issues (semiconductor physics, waveguides).

Continued implementation through the programming course.

Pre-requisites

EDP course on finite differences, 1st year EEEA.

Programming for scientific computing



Component

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In brief

- **Ametys Code:** N8EE22B
- **Open to exchange students:** Yes

Presentation

Objectives

Introduce students to the Fortran 90 language, which is still widely used in the field of numerical methods and scientific computing, through examples from the finite element course applied to waveguide problems.

Description

Introductory course to Linux and the Fortran language. The main syntax concepts are covered through independent exercise sessions and an application project. Interfacing with the Python language is covered at the end of the project.

Note: Development work must be carried out on Linux in order to allow students to deepen their knowledge of this operating system.

Pre-requisites

Programming basics, finite elements

Semestre 8 - Numerical Physics (PN)



ECTS
30 credits



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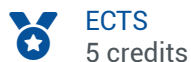
In brief

- **Ametys Code:** M8FP89Q7
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
MECATRONICS	UE				5 credits
Materials	UE				
Smart Electroactive Materials	UE				
Modeling of electromagnetic systems using analytical calculations	UE				
Thermal and Fluid Mechanics	UE				
NUMERICAL PROJECTS	UE				5 credits
Numerical Project	Matière				
SCIENTIFIC COMPUTING	UE				5 credits
Numerical simulation in optics	UE				
Numerical analysis 2	Matière				
Programming for scientific computing	Matière				
Optimal design of a rocket nozzle actuator	UE				
Finite elements for electromagnetism	Matière				
PHYSICAL PHENOMENA AND MODELING	UE				5 credits
Electromagnetic radiation and antennas	Matière				
Physical analysis of guiding structures	UE				
Project: Modelling of structures in EM	Matière				
APPLIED MATHEMATICS	UE				5 credits
Advanced linear algebra	UE				
Hilbertian analysis	UE				
Optimisation under constraints	Matière				
SOFT AND HUMAN SKILLS	UE				5 credits
Professional English 2.2 : Debates	Matière				
Second language	Choix				
Spanish	Matière				
Spanish	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
french (as a foreign language)	Matière				
LSF - S8	Matière				
Sports	Matière				
Careers and Management - Sem.8	Choix				
Leadership	Matière				
Entrepreneurship	Matière				
Citizenship	Matière				
Managership-S8	Matière				

MECATRONICS



Component
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In brief

- **Ametys Code:** M34HMH1J
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Materials	UE				
Smart Electroactive Materials	UE				
Modeling of electromagnetic systems using analytical calculations	UE				
Thermal and Fluid Mechanics	UE				

Materials



Component

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In brief

- **Ametys Code:** N8EE20A
- **Open to exchange students:** Yes

Presentation

Objectives

Be able to choose the right material during the design phase of an electromechanical system (mechanical materials, magnetic materials, and dielectric materials).

Acquire sufficient knowledge of materials (development, properties, treatments, etc.) to be able to communicate effectively with suppliers.

Description

The following topics will be covered in this course:

Characteristics and properties of materials

Manufacturing of materials

General use of the main families of materials

Pre-requisites

No prerequisites are necessary for this course.

Smart Electroactive Materials



Component

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In brief

- **Ametys Code:** N8EE20C
- **Open to exchange students:** Yes

Presentation

Objectives

- By the end of this course, students will have learned about several alternative solutions for electromechanical conversion.
- They will be able to describe the physical principles at work in piezoelectric, electro- and magnetostrictive devices, and shape memory alloys.

Description

- Review of the definition of smart materials.
- Description of the physical principles involved in magnetostriction, piezoelectricity, and shape memory alloys.
- Comparison of the electromechanical performance of the solutions and illustration of the fields of application.
- In-depth study of the principles and implementation of piezoelectric materials.

Modeling of electromagnetic systems using analytical calculations



Component

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Télécommunications

In brief

- **Ametys Code:** N8EE21C
- **Open to exchange students:** Yes

Presentation

Objectives

- By the end of this course, students will have mastered the equations and various analytical formulations used to describe the magnetic state of electromagnetic machines and devices.
- They will be able to establish an analytical model necessary for the preliminary design of electromagnetic systems and identify the influence of key parameters.

Description

- Formulate and justify simplifying assumptions to define a magnetostatic problem
- Solve a 2D magnetostatic problem in polar coordinates governed by a Laplace equation in magnetic vector potential
- Calculate and express the observable quantities of an electric machine based on its geometric and structural characteristics

- Apply the proposed method in the case of a simplified model of synchronous machines with permanent magnets, with or without slots
- List the main steps of this method in the case of a simplified model of a double-fed asynchronous machine and a direct current machine

Thermal and Fluid Mechanics



Component

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In brief

- **Ametys Code:** N8EE21E
- **Open to exchange students:** Yes

Presentation

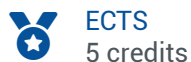
Objectives

By the end of this course, students will have assimilated the physical principles governing heat transfer and the associated equations.

Description

- Fluid statics
- Bernoulli's theorem
- Euler's theorem
- Pressure losses

NUMERICAL PROJECTS



In brief

- **Ametys Code:** M34HMGHF
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Numerical Project	Matière				

Numerical Project



Component

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In brief

- **Ametys Code:** M34HMGLG
- **Open to exchange students:** Yes

Presentation

Objectives

Lead a group project with a degree of autonomy.

Description

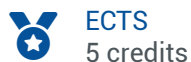
Study a physical phenomenon using existing or yet-to-be-developed numerical simulation tools.

Pre-requisites

EDP, Optimization, imperative programming in the first year.

Finite elements for electromagnetism, constrained optimization in the second year.

SCIENTIFIC COMPUTING



In brief

- **Ametys Code:** M34HMI7B
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Numerical simulation in optics	UE				
Numerical analysis 2	Matière				
Programming for scientific computing	Matière				
Optimal design of a rocket nozzle actuator	UE				
Finite elements for electromagnetism	Matière				

Numerical simulation in optics



Component

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In brief

- **Ametys Code:** N8EE11A
- **Open to exchange students:** Yes

Presentation

Objectives

This module is intended for future engineers who wish to explore the field of fiber optic sensors and sensor instrumentation.

Description

This module teaches the essentials of the field through lectures. A design project will further the learning process by proposing the modeling and simulation of a fiber optic sensor currently used in research

Numerical analysis 2



Component

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In brief

- **Ametys Code:** M34HMIIT
- **Open to exchange students:** Yes

Presentation

Objectives

This module aims to:

- understand some basic results and properties concerning interpolation and quadrature;
- understand how interpolation and quadrature are useful for defining single-step or multi-step methods for solving ordinary differential equations.

Description

The module covers two fundamental concepts in numerical analysis, namely interpolation and quadrature, and shows how they can be used to construct methods for solving ordinary differential equations. A tutorial session and two lab sessions allow students to apply the concepts covered in class.

Pre-requisites

None

Optimal design of a rocket nozzle actuator



Component

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d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8EE21B
- **Open to exchange students:** Yes

Presentation

Objectives

The design office "Optimal design of a rocket nozzle actuator" aims to introduce students to the use of optimization algorithms, in particular gradient descent, to design electrical machines efficiently.

Description

Students will learn to formulate machine design problems in terms of mathematical objectives and constraints, then apply numerical methods to optimize performance, such as efficiency, compactness, and energy losses. Emphasis will be placed on understanding and implementing different types of gradient descent, including stochastic and adaptive versions, adapted to electromagnetic systems. Students will use simulation tools to test and validate their optimal solutions in real-world machine design scenarios. Finally, through case studies and practical projects, they will develop skills in applying optimization algorithms to complex industrial problems, strengthening their ability to design high-performance and economically viable electrical machines.

Semestre 8 - Real-time automated systems (SATR)



ECTS
30 credits



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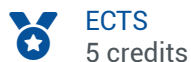
In brief

- **Ametys Code:** M8FP9235
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
CONTROLLED, NON LINEAR SYSTEMS	UE				5 credits
State space	UE				
Introduction to Non-linear control	UE				
Non-linear control	UE				
Automatic Tutorials	UE				
DIGITAL CONTROL	UE				5 credits
Digital control	UE				
Digital Control Project	UE				
Industrial automation	UE				
Automatic Control Systems Tutorials	UE				
ELECTRICAL SYSTEM ARCHITECTURES AND CONTROLS	UE				5 credits
Electric vehicle motor sizing / CVS-Machines design elements	LV2				
	facultative				
Converter control	UE				
Machine control	UE				
ZOE powertrain project	UE				
DISCRETE AND SAMPLED EVENT SYSTEMS	UE				5 credits
Polynomial control	UE				
Graphs and Scheduling	UE				
Identification (recursive methods)	UE				
Automatic Tutorials	UE				
Petri network	UE				
NETWORK AND REAL-TIME SYSTEMS ENGINEERING	UE				5 credits
Distributed Computer Systems	UE				
Industrial networks	UE				
Real-time systems	UE				
SOFT AND HUMAN SKILLS	UE				5 credits
Professional English 2.2 : Debates	Matière				
Second language	Choix				
Spanish	Matière				
Spanish	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
french (as a foreign language)	Matière				
LSF - S8	Matière				
Sports	Matière				
Careers and Management - Sem.8	Choix				
Leadership	Matière				
Entrepreneurship	Matière				
Citizenship	Matière				
Managership-S8	Matière				

CONTROLLED, NON LINEAR SYSTEMS



In brief

- **Ametys Code:** N8EE13
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
State space	UE				
Introduction to Non-linear control	UE				
Non-linear control	UE				
Automatic Tutorials	UE				

State space



Component

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In brief

- **Ametys Code:** N8EE13A
- **Open to exchange students:** Yes

Presentation

Objectives

- 1) Model continuous-time and discrete-time dynamic systems in state space,
- 2) Analyze the dynamic behavior of these systems based on their modeling in state space (poles, zeros, stability, controllability, observability, transfer functions, time response),
- 3) Synthesize state feedback control architectures and state feedback with continuous-time integral action,
- 4) Synthesize full-order and reduced-order observers,

Description

Using control architectures based on low-order linear controllers such as P, PI, or PID allows for the control of certain types of systems with very good performance, but what if the open-loop system is already of order 4, 5, 10, 100, etc., as is the case for the vast majority of systems around us and in industry (electrical systems such as converters, electric actuators, and networks, but also renewable energy production systems, vehicles, robots, production lines, heating systems, economic systems, etc.)? The correctors mentioned above are effective over a specific frequency range but have limited effectiveness when it comes to controlling the dynamic behavior of a high-order system, especially when its poles are scattered across the frequency spectrum. This course

introduces a modeling formalism known as "state space" modeling, which allows for the analysis and synthesis of appropriate control laws for such systems, regardless of their order, which we encounter on a daily basis.

Pre-requisites

Course "N7EE05C: Synthesis of Correctors and Control Architectures"

Course "N7EE05B: Sampled Systems"

Algebra and matrix operations (matrix product, eigenvalues and eigenvectors, determinant, matrix inversion, diagonalization)

Laplace transform, Integral calculus,

Introduction to Non-linear control



Component

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In brief

- **Ametys Code:** N8EE13B
- **Open to exchange students:** Yes

Presentation

Objectives

Be able to...

- characterize a nonlinear system using the first harmonic method and identify the method's domain of validity,
- synthesize a linear corrector to modify the characteristics of self-oscillation,
- characterize a nonlinear system using the phase plane method
- adjust simple control elements (threshold, hysteresis, feedback coefficient, linear corrector) in order to obtain a given performance.

Description

1. Introduction to nonlinear system control

Limitations of linear methods, definition of a nonlinear system and its domain of definition, the most common nonlinearities, methods of study and their classification

2. First harmonic method

Principles and Fourier series, method for calculating equivalent transmittance, stability of self-oscillations, examples of temperature control in TOR, saturated amplifier, linear correction of nonlinear systems

3 Phase plane method

Principle, trajectory calculation method, principles of linear correction of nonlinear systems in the phase plane, state representation

Pre-requisites

- Fourier series decomposition,
- Calculations with complex numbers,
- Solving first- and second-order differential equations,
- Basics of matrix calculus,
- N6EE02: Signals & Automation,
- N6EE03: Electrical circuits and systems.

Non-linear control



Component

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In brief

- **Ametys Code:** N8EE13C
- **Open to exchange students:** Yes

Presentation

Objectives

This course aims to introduce students to the analysis and control of non-linear systems.

Description

Upon completion of this course, students will be able to:

Identify the nature of nonlinear phenomena present in a given system (saturation, rotation, bilinearity, coupling between dynamics, discontinuities, etc.);

Calculate the equilibrium points of a nonlinear system;

Distinguish between different concepts of stability (local, global, asymptotic, exponential);

Apply Lyapunov's first method to analyse the stability of a nonlinear system, in particular by studying the stability of the linearised system around an operating point;

Apply Lyapunov's second method to analyse the stability of the nonlinear system, particularly for large signals, and estimate the stability domain if necessary;

Synthesise different types of nonlinear control laws to ensure optimal closed-loop performance (bang-bang control, sliding mode control, linearising state feedback control).

In addition to the lectures, tutorials allow students to manipulate these concepts and apply them to the analysis and control of real systems with nonlinearities. Finally, a project involving the synthesis and implementation of non-linear control laws for a wheeled mobile robot trajectory tracking problem is proposed. This work is carried out in simulation, within the framework of a supervised design office.

Pre-requisites

N8EE13A - State Space

N8EE13B - Nonlinear Systems

Automatic Tutorials



Component

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d'Informatique
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Télécommunications

In brief

- **Ametys Code:** N8EE13D
- **Open to exchange students:** Yes

Presentation

Objectives

The aim of this series of practical exercises is to illustrate the fundamental concepts of automatic control, with an emphasis on modelling, stability analysis, and the synthesis of control laws for dynamic systems. The exercises are designed to develop practical skills in simulation and experimentation, while reinforcing understanding of theoretical concepts.

Description

This series of practical assignments will focus on the concepts of

- (i) State Feedback Control and Observers for an Unstable System,
- (ii) Lyapunov Stability and Non-Linear Control of a Non-Linear System, and
- (iii) Study of Self-Oscillations in Non-Linear Systems. The work carried out will enable students to acquire the following skills:

Process modelling: Identification of dynamic equations and physical parameters;

Stability analysis: Calculation of equilibrium points of a nonlinear system, local stability analysis in the sense of Lyapunov, estimation of the stability domain and visualisation of system trajectories using a graphical tool (pplane);

State feedback control law synthesis: Ensuring accuracy and transient behaviour compatible with the operating domain;

Design of an observer-based control system: Reconstruction of unmeasurable or poor-quality system states using a state observer, then insertion of the observer into a control loop;

Design of sliding mode control laws for a highly non-linear system;

Simulation of different solutions on Matlab/Simulink;

Experimental validation on different models: pendulum-type device (crane or inverted pendulum), characterised by high order (4°) and the presence of unstable poles, non-linear ball-on-rail system, synchronisation of the position of three discs connected by torsion wires driven by a brushless motor.

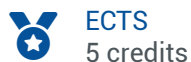
Pre-requisites

N8EE13A – State Space

N8EE13B – Nonlinear Systems

N8EE13C – Nonlinear Control

DIGITAL CONTROL



In brief

- **Ametys Code:** N8EE14
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Digital control	UE				
Digital Control Project	UE				
Industrial automation	UE				
Automatic Control Systems Tutorials	UE				

Digital control



Component

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In brief

- **Ametys Code:** N8EE14A
- **Open to exchange students:** Yes

Presentation

Objectives

The main objective is to understand the various issues encountered when digitally controlling a real-time system under severe time constraints.

The first chapter will be devoted to a general introduction to digital control and the concepts of open-loop and closed-loop systems. Details of an architecture dedicated to real-time digital control will then be presented.

The second chapter will focus on the concept of sensors (accuracy, bandwidth, linearity, etc.) and on the various analogue-to-digital and digital-to-analogue conversion technologies (single and dual ramp, successive approximation, flash, pipeline, etc.).

The third chapter will be a comparative study of the different modes of process control, in particular polling mode and interrupt mode. The advantages and disadvantages of each will then be examined.

The fourth and final chapter will be devoted to the study of the evolution of microprocessor architectures with a view to increasing performance. The following architectures will then be described: RISC/CISC, execution pipeline, superscalar, VLIW, Harvard, memory cache, introduction to multiprocessing.

Description

The digital control of a real-time system places very heavy constraints on the digital architecture used, which must therefore be very different from the architectures traditionally used on a PC. These constraints will therefore be analysed and translated into requirements for the digital architecture.

Digital system control also highlights the central importance of sensors in determining the status of the system to be controlled. We will therefore propose, on the one hand, a study of the main properties and defects of sensors and, on the other hand, a study of analogue-to-digital and digital-to-analogue conversion systems.

Performance requirements (digital calculation, rapid sampling) in the context of digital control will lead us to study the latest advances in microprocessor architecture with a view to increasing performance.

Pre-requisites

N5EE03-Logic System Design

N5EE02- Basic Elements of Algorithms, Programming and Computer Architecture

N7EE01- Computer System Architecture and Development

Digital Control Project



Component

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In brief

- **Ametys Code:** N8EE14B
- **Open to exchange students:** Yes

Presentation

Objectives

Develop digital speed control for a mechatronic system consisting of a power converter and a brushless DC motor. The system is controlled by a digital system comprising an FPGA and an SOPC processor.

Description

The aim is to encourage students to develop all the functionalities required for speed control of a brushless DC machine. The work is carried out in pairs, each pair having a model for experimental purposes.

Autopilot control is achieved using digital control logic implementing pulse width modulation developed in VHDL language and position sensors.

A speed sensor is then designed, again in VHDL, to enable the measurements required for speed control.

The students then design the entire speed control algorithm, from simulation to implementation on a processor using the C language.

Pre-requisites

- Concept of autopilot control of electrical machines
- Control of a pulse width modulation energy converter
- Sizing of a continuous regulator and its digital equivalent

Industrial automation



Component

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In brief

- **Ametys Code:** N8EE14C
- **Open to exchange students:** Yes

Presentation

Objectives

Learn how to model and program sequential logic on a processor.

Description

Modelling sequential systems with discrete events. Functional modelling and sequencing. State machines and GRAFCET (SFC Sequential Functional Chart). Equivalent logic equations and implementation of structured executable code on a single processor. PLC (Programmable Logic Computer) technology.

Pre-requisites

Combinational logic, sequential logic, operating systems, processor operation

Automatic Control Systems Tutorials



Component

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In brief

- **Ametys Code:** N8EE14D
- **Open to exchange students:** Yes

Presentation

Objectives

Handle industrial automation programming hardware and software.

Understand and ensure the real-time operation of automation systems (simultaneous crossings, exchange of words via industrial fieldbus communication).

M340, Transporter, FESTO, TSX-micro, TSX-Premium, Rotary Store, Pneumatic Robot Arm, Virtual Factory, FipWay...

Description

Practical implementation on various software and operating parts. Development environment, Festo, Unity, PL7 Devices: transfer table, rotary magazine, virtual factory, vertical distributor

Pre-requisites

Automation and programmed logic course

ELECTRICAL SYSTEM ARCHITECTURES AND CONTROLS



ECTS
5 credits



Component
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In brief

- **Ametys Code:** N8EE15
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Electric vehicle motor sizing / CVS-Machines design elements	LV2 facultative				
Converter control	UE				
Machine control	UE				
ZOE powertrain project	UE				

Electric vehicle motor sizing / CVS-Machines design elements



Component

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In brief

- **Ametys Code:** ELP8
- **Open to exchange students:** Yes

Presentation

Objectives

The objective is to equip future engineers with the skills necessary to develop specifications for an electric vehicle motor and then determine the main dimensions of this motor in the case of a permanent magnet synchronous motor. Students will acquire the fundamental knowledge and skills required for the design and optimization of couplings between power converters and electrical machines. They will gain an understanding of electrical interactions, control constraints, and efficiency requirements in order to effectively size and integrate these systems into industrial and energy applications.

Description

Le cours « **Dimensionnement moteur pour véhicule électrique** » aborde les principes fondamentaux du choix et du dimensionnement des machines électriques utilisées dans les véhicules à propulsion électrique. Les étudiants y apprennent à relier les exigences dynamiques du véhicule (couple, vitesse) aux caractéristiques du moteur et de son système d'alimentation. Le programme couvre les moteurs synchrone à aimants permanents et leurs méthodes de modélisation au premier ordre. Le cours « **Elements de conception des associations CVS-machines** » aborde les principes de couplage entre les convertisseurs statiques (CVS) et les machines électriques (asynchrones, synchrones, à aimants permanents, etc.). Il présente les modèles électriques, les

stratégies de contrôle, les contraintes de puissance et de rendement. Des études de cas et des simulations permettront d'illustrer les options de conception et d'intégration en fonction des applications (traction, systèmes intégrés au réseau).

Pre-requisites

Knowledge of power electronics and electrical machines.

Converter control



Component

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In brief

- **Ametys Code:** N8EE15C
- **Open to exchange students:** Yes

Machine control



Component

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In brief

- **Ametys Code:** N8EE15D
- **Open to exchange students:** Yes

Presentation

Objectives

- 1- Become familiar with the various components of a variable speed drive for three-phase electric machines.
- 2- Learn how to model electric machines for control purposes.
- 3- Implement vector controls for three-phase electric machines.
- 4- Synthesise scalar controls for synchronous and asynchronous machines.
- 5- Raise awareness of the issues involved in high-speed operation.

Description

This course enables students to apply the skills they have acquired in automation and electrical machine modelling to design variable speed drives for inverter-powered electrical machines.

To achieve this objective, the first chapter presents the principle of DC machine control, which forms the basis for the control of three-phase electrical machines. The different models of synchronous and asynchronous machines are reviewed, specifying the limitations of their use for the synthesis of control laws.

Next, using Park's transform, models dedicated to the control of synchronous and asynchronous machines are presented, detailing the specific features of each type of machine. These models serve as the basis for the design of control systems in variable speed drives for different machines. Methods for synthesising control loops (electromagnetic torque, speed, position) are presented, discussing the limitations imposed by the machine (current limitation) and by the inverter (limited voltage). Pulse width modulation (PWM) methods for inverter control by continuous controllers are also presented.

Finally, the possibility of reaching different operating points in the torque-speed plane is discussed, detailing the strategies for calculating references for both types of machines. Issues specific to high-speed control are introduced.

Pre-requisites

N7EE03B - Electromagnetic modelling of machines

N7EE03F - Principles and structures of electrical machines

N7EE05C - Synthesis of correctors and control architectures

N7EE04D - Modulation and filtering of voltage inverters

ZOE powertrain project



Component

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In brief

- **Ametys Code:** N8EE15E
- **Open to exchange students:** Yes

Presentation

Objectives

- 1) Acquire a cross-disciplinary overview of the skills taught within the department's energy specialisation in order to better understand the links and complementarity between the different areas of knowledge and skills (design of electromechanical actuators, power electronics, automation and control)
- 2) Design of electromechanical actuators: Acquire a methodology for the analytical pre-dimensioning of three-phase electric machines
- 3) Power electronics: Understand the interactions between converters and electric machines when they are combined, and model the achievable operating limits in the torque-speed plane
- 4) Automatic control: Design scalar and vector control architectures for three-phase electric machines, and develop strategies for controlling their torque

Description

The project consists of designing an electromechanical chain for use in the traction system of a city car-type electric vehicle. This design involves a comprehensive approach which, based on a given set of specifications, begins with an analysis of the specifications and the sizing of the electric motor. Once the motor has been sized, it is powered by an inverter connected to the vehicle's battery. The resulting electromechanical chain is then analysed to determine the operating limits of the assembly. This

analysis is essential to understanding how to design the control strategy for the assembly. The system control architecture and associated control strategies are then developed to enable the system to achieve the various operating points required by the specifications.

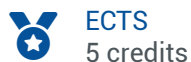
Pre-requisites

Course 'N8EE15D - Machine Control'

Course 'N8EE15C - Converter Control'

Course 'N8EE15F - Motor Sizing for Electric Vehicles / Design Elements of CVS-Machine Combinations'

DISCRETE AND SAMPLED EVENT SYSTEMS



In brief

- **Ametys Code:** N8EE16
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Polynomial control	UE				
Graphs and Scheduling	UE				
Identification (recursive methods)	UE				
Automatic Tutorials	UE				
Petri network	UE				

Polynomial control



Component

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In brief

- **Ametys Code:** N8EE16A
- **Open to exchange students:** Yes

Presentation

Objectives

Master the design of synthesis methods for defining discrete control laws to be implemented on a digital computer

Description

- I Introduction and General Information
 - Brief history
 - Structure of a digital control system
 - Representation of discrete linear systems
- II Frequency approach
 - Digitisation of standard controllers
 - Direct frequency synthesis
- III Synthesis of digital controllers
 - Formalism and notation
 - Generalised controller
 - The RST controller

The Smith predictor

IV Synthesis of a discrete state feedback

Pole placement

Addition of an integral action

V Discrete state observers

Full-order observer

Reduced-order observer

VI Anti-saturation devices

Pre-requisites

Z-transform

Sampled systems

Continuous linear control systems

Graphs and Scheduling



Component

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In brief

- **Ametys Code:** N8EE16B
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand the basic concepts and terminology of graphs
- Identify and model issues from different fields or specifications in the form of identification, enumeration or optimisation problems in a graph.
- Master methods for identifying and enumerating paths, trees, circuits and stable points in a graph.
- Solve polynomial optimisation problems on graphs: finding the shortest path, minimum weight spanning tree, maximum matching, etc.
- Apply graph algorithms to real-world problems from different fields, including project management

Description

This course provides an introduction to graphs and related algorithms, with an emphasis on their application to concrete problems from different fields.

Pre-requisites

None

Identification (recursive methods)



Component

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In brief

- **Ametys Code:** N8EE16C
- **Open to exchange students:** Yes

Presentation

Objectives

Design online identification methods for representing linear systems

Description

General information

1. Least squares estimation
2. The gradient method
 - "a priori" prediction
 - "a posteriori" prediction
3. Recursive least squares
4. Some important considerations

- excitation signal
- whiteness of the prediction error sequence

5. Extended least squares

Application:

Identification of a system with slowly varying parameters

Pre-requisites

Sampled systems

Z transform

Transfer function

Automatic Tutorials



Component

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In brief

- **Ametys Code:** N8EE16D
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand the fundamental concepts and terminology of Petri nets.
- Identify and model discrete event systems
- Analyse the structural and behavioural properties of Petri nets.
- Understand the limitations of the classical model and the principle of extensions
- Learn how to use graphical modelling, editing and analysis software such as TINA with application to concurrent and distributed systems

Description

This course examines Petri nets used to solve problems in concurrent and distributed systems, where multiple processes or events occur simultaneously and interact in complex ways. They enable the modelling and analysis of scenarios such as task

synchronisation, shared resource management, deadlock detection, and the verification of safety and liveness properties in dynamic and unpredictable environments.

Pre-requisites

- Linear algebra
- Graphs

Petri network



Component

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In brief

- **Ametys Code:** N8EE16E
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand the fundamental concepts and terminology of Petri nets.
- Identify and model discrete event systems
- Analyze the structural and behavioral properties of Petri nets.
- Understand the limitations of the classical model and the principle of extensions.
- Learn how to use graphical modeling, editing, and analysis software such as TINA with application to concurrent and distributed systems.

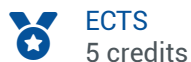
Description

This course studies Petri nets used to solve problems in concurrent and distributed systems, where several processes or events occur simultaneously and interact in complex ways. They can be used to model and analyze scenarios such as task synchronization, shared resource management, deadlock detection, and verification of safety and liveness properties in dynamic and unpredictable environments.

Pre-requisites

- Linear algebra
- Graphs

NETWORK AND REAL-TIME SYSTEMS ENGINEERING



In brief

- **Ametys Code:** N8EE17
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Distributed Computer Systems	UE				
Industrial networks	UE				
Real-time systems	UE				

Distributed Computer Systems



Component

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In brief

- **Ametys Code:** N8EE17A
- **Open to exchange students:** Yes

Presentation

Objectives

Current computer systems, whether embedded (avionics, automotive) or not (production systems, for example), are distributed, meaning that applications and services are implemented on a network of computers. Distributed programming can be defined as a set of communicating software entities that perform a system function.

The objective of this course is to describe and put into practice (1) the basic concepts of distributed programming according to the client-server model, as well as (2) the principles of distributed algorithms.

Description

Distributed programming is illustrated using BSD Sockets to implement client-server applications with different communication protocols, datagram (UDP) and connected (TCP). Different server models are presented, from sequential servers in datagram mode to multi-threaded servers in connected mode. The different models are implemented in a design office on a network of Linux machines.

Distributed programming is approached from the perspective of reliable message delivery to a group of processes and the issue of consensus.

A design office invites students to implement a reliable distribution mechanism and use it in a peer-to-peer application.

Pre-requisites

A good knowledge of algorithms, IP network protocols, C programming, operating system principles, and in particular Linux, is required.

Industrial networks



Component

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In brief

- **Ametys Code:** N8EE17B
- **Open to exchange students:** Yes

Presentation

Objectives

This module presents the specific features of network architectures in the context of applications that must meet time constraints. It draws on a set of significant examples from different application contexts, in particular the automotive, aeronautics, and space industries.

Description

Shared communication architectures have been used since the 1980s for real-time applications, replacing dedicated links, which were far too costly in terms of cabling and did not scale. Initially, fieldbus-type solutions, dedicated to specific application contexts, became the norm. These solutions control communication latencies but often offer limited throughput. They are therefore gradually being replaced by real-time Ethernet solutions, which offer much higher throughput and better system integration into their environment. The module is structured as follows.

- We introduce the general issues surrounding real-time communications and the different communication paradigms used.
- We study Controller Area Network (CAN), the associated temporal analysis methods, and protocol developments.

- We study the Airborne Switched Ethernet (AFDX) network with a particular focus on the worst-case analysis implemented by manufacturers.
- We highlight the problems posed by sharing a real-time Ethernet network between flows with different levels of criticality. We present the Ethernet TSN solution.
- We present the Mil-Std-1553 and Spacewire technologies used in the space sector.

Real-time systems



Component

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In brief

- **Ametys Code:** N8EE17C
- **Open to exchange students:** Yes

Presentation

Objectives

Critical computer systems are omnipresent in our daily lives. They control our cars, fly our planes, distribute our electricity, etc. These systems are considered critical because their failure can have dramatic consequences, whether financial, material, or human. Critical systems must therefore offer strong guarantees regarding the correctness of their execution and meet certain responsiveness requirements.

We will see how a real-time operating system can help provide these guarantees. We will present rigorous analysis methods for ensuring system responsiveness. We will also show how these results can be used to help optimize system design.

Description

In the first part, the module will focus on traditional methods for sharing a computer between several tasks. This issue will be addressed through the creation of a simple task scheduler that can be implemented on an Arduino-type microcontroller. We will thus present the specific features of a real-time operating system designed for critical embedded systems, and in particular real-time scheduling algorithms. These algorithms enable the system's schedulability to be analyzed, which makes it possible to formally prove the correctness of the system's responsiveness.

In the second part, we will present the OSEK/VDX standard, which is widely used in real-time operating systems in the automotive sector and forms the basis of the AUTOSAR standard. The concepts will be applied in a design office in an embedded context with the Trampoline RTOS real-time operating system.

Pre-requisites

A good knowledge of algorithms, C programming, and operating system principles, particularly Linux, is required.

Semestre 8 - Mechatronic System (SM)



ECTS
30 credits



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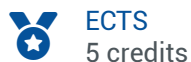
In brief

- **Ametys Code:** M8FPAGMW
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
CONTROLLED, NON LINEAR SYSTEMS	UE				5 credits
State space	UE				
Introduction to Non-linear control	UE				
Non-linear control	UE				
Automatic Tutorials	UE				
DIGITAL CONTROL	UE				5 credits
Digital control	UE				
Digital Control Project	UE				
Industrial automation	UE				
Automatic Control Systems Tutorials	UE				
ELECTRICAL SYSTEM ARCHITECTURES AND CONTROLS	UE				5 credits
Electric vehicle motor sizing / CVS-Machines design elements	LV2				
	facultative				
Converter control	UE				
Machine control	UE				
ZOE powertrain project	UE				
ACTUATION MATERIALS	UE				5 credits
Materials	UE				
Smart Electroactive Materials	UE				
Finite element methods	UE				
Lagrangian approach to electromechanical systems	Matière				
ANALYTICAL AND PHYSICAL TOOLS FOR MECHATRONICS	UE				5 credits
System optimization and optimal design	UE				
Optimal design of a rocket nozzle actuator	UE				
Modeling of electromagnetic systems using analytical calculations	UE				
Thermal and Fluid Mechanics	UE				
SOFT AND HUMAN SKILLS	UE				5 credits
Professional English 2.2 : Debates	Matière				
Second language	Choix				
Spanish	Matière				
Spanish	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
french (as a foreign language)	Matière				
LSF - S8	Matière				
Sports	Matière				
Careers and Management - Sem.8	Choix				
Leadership	Matière				
Entrepreneurship	Matière				
Citizenship	Matière				
Managership-S8	Matière				

ACTUATION MATERIALS



In brief

- **Ametys Code:** N8EE24
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Materials	UE				
Smart Electroactive Materials	UE				
Finite element methods	UE				
Lagrangian approach to electromechanical systems	Matière				

Finite element methods



Component

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In brief

- **Ametys Code:** N8EE20D
- **Open to exchange students:** Yes

Presentation

Objectives

Approximate solution of partial differential equations using the finite element method, applied to physical problems frequently encountered by electronic engineers.

Description

Principles of finite elements

Variational formulation

Basis functions and discretization

1D and 2D meshes

Solution.

Application BE using the Matlab PDE toolbox on problems related to electronics (semiconductor physics, waveguides)

Pre-requisites

EDP course using finite differences, 1st year EEEA

Lagrangian approach to electromechanical systems



Component

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In brief

- **Ametys Code:** N8EE24A
- **Open to exchange students:** Yes

Presentation

Objectives

Be able to easily establish the law of behavior of a complex system using Lagrangian mechanics.

Description

Advantages of Lagrangian mechanics:

It allows the law of behavior of a system to be established by analyzing its energy exchanges with the outside world, unlike Newtonian mechanics, which allows the law of behavior of a system to be established by analyzing the forces applied to each of the solids that compose it. Thus:

- There is no need to manipulate all the forces that do not exchange energy with the system, such as connection forces. This simplifies the study of complex systems with a large number of solids (and therefore connections).
- The energy-based approach allows multiphysical systems to be handled.
- It is a scalar (energy) approach rather than a vector (force) approach.

- There is no longer any need to isolate each solid.

Course content: (6 lecture slots, 1 tutorial slot)

- Review of the main concepts of mechanics (reference frames, forces, moments, kinematic connections, etc.).
- Review of the principles of Newtonian mechanics (PFD).
- Presentation of concepts used in Lagrangian mechanics (mobility of a system, generalized coordinates, energies).
- Presentation of Lagrangian mechanics equations based on Newtonian mechanics equations.
- Presentation of the concept of virtual mobility.
- Adjustment of equations to address electromechanical issues.

ANALYTICAL AND PHYSICAL TOOLS FOR MECHATRONICS



ECTS
5 credits



Component
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In brief

- **Ametys Code:** N8EE25
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
System optimization and optimal design	UE				
Optimal design of a rocket nozzle actuator	UE				
Modeling of electromagnetic systems using analytical calculations	UE				
Thermal and Fluid Mechanics	UE				

System optimization and optimal design



Component

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In brief

- **Ametys Code:** N8EE21A
- **Open to exchange students:** Yes

Presentation

Objectives

- By the end of this course, students will have learned how to formulate a constrained optimization problem with a view to solving it.
 - They will be able to describe the problem in terms of an objective function under constraints and use numerical tools to solve it optimally.
-

Description

- Illustration of design problems formalized as optimization problems with constraints.
- Review of unconstrained optimization: mathematical theorems and gradient algorithms, optimal step gradient, Newton and quasi-Newton.
- Optimization with constraints on variables: first simple projection algorithm.
- Mathematical formalization of optimization problems with constraints.
- Presentation of Penalty Methods

- Definition of the Lagrange Function
- KKT Theorem (Karush-Khun-Tucker)
- Uzawa Algorithm, Active-set, SQP, Interior Point Algorithm

Semestre 8 - Electrical systems of the future (SEF)



ECTS
30 credits



Component
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Télécommunications

In brief

- **Ametys Code:** M8FPCGCR
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
CONTROLLED, NON LINEAR SYSTEMS	UE				5 credits
State space	UE				
Introduction to Non-linear control	UE				
Non-linear control	UE				
Automatic Tutorials	UE				
DIGITAL CONTROL	UE				5 credits
Digital control	UE				
Digital Control Project	UE				
Industrial automation	UE				
Automatic Control Systems Tutorials	UE				
ELECTRICAL SYSTEM ARCHITECTURES AND CONTROLS	UE				5 credits
Electric vehicle motor sizing / CVS-Machines design elements	LV2				
	facultative				
Converter control	UE				
Machine control	UE				
ZOE powertrain project	UE				
IMPLEMENTATION OF SWITCHING CELLS	UE				5 credits
Switching Mechanisms in Static Converters	UE				
Thermal	UE				
Static Converter close control project	UE				
RENEWABLE ENERGIES AND FACTS	UE				5 credits
Introduction to FACTS	UE				
Renewable energy: wind and solar power	UE				
SOFT AND HUMAN SKILLS	UE				5 credits
Professional English 2.2 : Debates	Matière				
Second language	Choix				
Spanish	Matière				
Spanish	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
french (as a foreign language)	Matière				
LSF - S8	Matière				
Sports	Matière				
Careers and Management - Sem.8	Choix				
Leadership	Matière				
Entrepreneurship	Matière				
Citizenship	Matière				
Managership-S8	Matière				

IMPLEMENTATION OF SWITCHING CELLS



ECTS
5 credits



Component
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In brief

- **Ametys Code:** N8EE18
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Switching Mechanisms in Static Converters	UE				
Thermal	UE				
Static Converter close control project	UE				

Switching Mechanisms in Static Converters



Component

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Télécommunications

In brief

- **Ametys Code:** N8EE18A
- **Open to exchange students:** Yes

Presentation

Objectives

Know how to select and size a power semiconductor component. Know how to interpret switching waveforms. Know how to develop a simple model capable of accounting for dynamic switching behavior. Be familiar with the main techniques for reducing switching stresses (suffered or emitted) and reducing losses at the power circuit, component, and driver circuit levels.

Description

In principle, this course follows the following outline:

- Presentation of the physical mechanisms involved and power semiconductor technologies: unipolar, bipolar, 2DEG HEMT, Si substrate, SiC, GaN, new materials, and advanced hybrid components. Current wide-bandgap and future ultra-wide-bandgap technologies.
- Review of the fundamentals of DC/DC cell switching. Introduction to vocabulary and definitions.

- Development of static and dynamic models using equivalent circuit elements of MOSFET and IGBT transistors. Case of RC-IGBT. Introduction to the PN junction diode and Schottky barrier diode models. In-depth study of nonlinear modeling of structural capacitances. Analysis of reverse conduction in the third quadrant of the MOSFET.
- Application of reverse conduction of the MOSFET in DC/DC "synchronous buck" and AC/DC "synchronous rectification."
- Analysis of "hard" switching: modeling of di/dt , dv/dt , oscillations, and degrees of freedom on loss-EMI tradeoffs. Overcurrent, overvoltage, and oscillations: reduction techniques. Link to the 3A course – Reliability.
- Technology: reduction of parasitic switching loop inductance using busbar power circuits on "plates" or multilayer PCBs. Reduction of the grid loop. Introduction to power integration.
- Principles of "soft" switching (snubber) and switching aids.
- Example of a quasi-resonant converter.
- Introduction to "soft" switching: DC/DC converters on LC filters with large ripple. Properties, advantages, disadvantages, and areas of application.
- Link to DC/AC topologies: PWM "hard" switching and full-wave "soft" switching (introduction to course 3A CERE).

Two tutorials follow the last lecture, allowing students to practice analyzing switching waveforms on PLECS and using degrees of freedom on the gate driver to balance switching loss reduction and dynamic constraint control (di/dt , dv/dt).

Pre-requisites

Course 1A and specialization in power electronics.

Thermal



Component

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In brief

- **Ametys Code:** N8EE18B
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of this course and the accompanying design office, students will be able to produce a nodal model of a thermal problem.

The design office, divided into two parts, also allows students to use digital tools to successfully design the cooling system for a power electronics converter.

Description

Course outline:

- Thermal engineering refresher – Heat equation – Conduction
 - Convection
 - Radiation
 - Nodal method
- Semiconductor thermodynamics
- Current research and prospects

Five lecture sessions are followed by a design office session during which students will be able to put modeling methods and various digital tools into practice.

The design office report serves as the assessment for this module.

Static Converter close control project



Component

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In brief

- **Ametys Code:** N8EE18C
- **Open to exchange students:** Yes

Presentation

Objectives

Master the real-time constraints associated with the digital control of a static converter (switching cell)

Discover and implement FPGA and SoftCore SoC processor components

Discover and implement computing architectures with tight time constraints (qq 10us)

Set up and test digital control laws with the processor and FPGA

Implement a DCPFC link using two switching cells with the techniques and tools provided

Description

Controlling a switching cell presents a number of difficulties, mainly due to the fact that these systems handle significant power (several kW) and that the cell's power switches operate at high frequencies (several tens of kHz). In a highly time-constrained environment, it is proposed to implement digital current control in a switching cell.

Pre-requisites

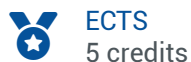
N5EE03-Logic System Design

N5EE02-Basic Elements of Algorithms, Programming, and Computer Architecture

N7EE01-Computer System Architecture and Development

N8EE14-Digital Control

RENEWABLE ENERGIES AND FACTS



Component
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Télécommunications

In brief

- **Ametys Code:** N8EE19
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Introduction to FACTS	UE				
Renewable energy: wind and solar power	UE				

Introduction to FACTS



Component

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In brief

- **Ametys Code:** N8EE19A
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the principles of reactive power control in electrical power transmission networks.

Description

This course is an introduction to electronic power devices for reactive power control in electrical power transmission networks. The principles of parallel and series compensation on power lines are presented. Applications based on reactors controlled by thyristors and switching dimmers are presented.

Pre-requisites

Methods for modeling and studying electrical power transmission networks.

Renewable energy: wind and solar power



Component

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In brief

- **Ametys Code:** N8EE19B
- **Open to exchange students:** Yes

Presentation

Objectives

Discover two renewable technologies for electricity generation: photovoltaic and wind power.

Description

This course presents the technical and economic aspects of photovoltaic and wind power.

Photovoltaic: from photovoltaic cells to systems, solar radiation, photovoltaic conversion, photovoltaic panels, power plants, cost, environmental impact.

Wind power: characterization of wind resources, effects of altitude and wake, theoretical elements (Betz limit) on wind power production and the energy efficiency of wind turbines; mechanical control through blade adjustment, from start-up to safe shutdown.

Composition of electric wind turbines: nacelles with and without speed multipliers.

Semestre 8 - Artificial intelligence for information processing (IATI)



ECTS
30 credits



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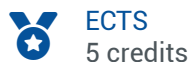
In brief

- **Ametys Code:** M8FPDU2A
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
APPLIED MATHEMATICS	UE				5 credits
Advanced linear algebra	UE				
Hilbertian analysis	UE				
Optimisation under constraints	Matière				
DIGITAL SYSTEM ARCHITECTURE	UE				5 credits
Synchronous design of digital systems	Matière				
FPGA technology	UE				
DSP	UE				
IMAGE AND SIGNAL PROCESSING MODELING	UE				5 credits
Image processing	UE				
Image Project	Matière				
Modeling	UE				
Elective Course: Advanced Study in IATI	Bloc				10 credits
Advanced Study SIA	Choix				
SIGNAL ADVANCED METHODS	UE				5 credits
Signal representation and analysis	Matière				
Optimal filtering	Matière				
Multivariate analysis	Matière				
Inverse problems	Matière				
AI FUNDAMENTALS	UE				5 credits
Information Theory	Matière				
Introduction to Deep Learning	Matière				
Statistics - advanced methods	Matière				
Computational statistics	Matière				
Advanced Study TSE	Choix				
SIGNAL ADVANCED METHODS	UE				5 credits
Signal representation and analysis	Matière				
Optimal filtering	Matière				
Multivariate analysis	Matière				
AI INTRODUCTION	UE				5 credits
Introduction to Deep Learning	Matière				
General AI integration: first hardware integration	Matière				
SOFT AND HUMAN SKILLS	UE				5 credits
Professional English 2.2 : Debates	Matière				
Second language	Choix				
Spanish	Matière				
Spanish	Matière				
Chinese	Matière				
Italian	Matière				
Japanese	Matière				
Russian	Matière				
German	Matière				
french (as a foreign language)	Matière				
LSF - S8	Matière				
Sports	Matière				
Careers and Management - Sem.8	Choix				
Leadership	Matière				
Entrepreneurship	Matière				

DIGITAL SYSTEM ARCHITECTURE



In brief

- **Ametys Code:** M34HLK4D
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Synchronous design of digital systems	Matière				
FPGA technology	UE				
DSP	UE				

DSP



Component

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In brief

- **Ametys Code:** N8EE03D
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand the architecture and specifications of a DSP compared to a conventional microcontroller.
- Master programming tools and languages.
- Understand the need for code optimization for implementation on embedded targets.

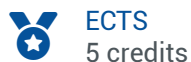
Description

This course is divided into two parts: Lectures and Practical Work. The lectures will cover the role of a Digital Signal Processor (DSP) within the signal processing chain. Students will then learn about the specific hardware and software features of a DSP. The final part of the course is dedicated to the different programming languages used for a DSP (C and Assembler). The practical work part is divided into four 3.5-hour sessions. The first part is dedicated to mastering the development software. In the second part, students will have to implement FSK modulation on an embedded target.

Pre-requisites

- C and Assembler languages
- Microcontroller Architecture and Programming

IMAGE AND SIGNAL PROCESSING MODELING



Component
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In brief

- **Ametys Code:** M34HLLP8
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Image processing	UE				
Image Project	Matière				
Modeling	UE				

Image processing



Component

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In brief

- **Ametys Code:** N8EN11A
- **Open to exchange students:** Yes

Presentation

Objectives

- 1) Introduction to the main digital image processing techniques: encoding and compression, enhancement and restoration, contour detection and segmentation, so that students gain an overview of existing conventional techniques.
- 2) Guided discovery of segmentation approaches through practical work: from the most conventional approaches, such as mean shift, to the most recent superpixel-based approaches.

Pre-requisites

Completion of first-year courses.

Useful info

Place

➤ Toulouse

Image Project



Component

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Télécommunications

In brief

- **Ametys Code:** M34HLLTC
- **Open to exchange students:** Yes

Presentation

Objectives

The objective of the image project is to explore a topic covered in image processing (e.g., segmentation, restoration, color manipulation) in greater depth and to implement a relatively recent algorithm that addresses one of these issues.

Modeling



Component

École Nationale
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In brief

- **Ametys Code:** N8EN11B
- **Open to exchange students:** Yes

Presentation

Objectives

- 1) Learn how to implement a complete rendering chain through practical exercises.
 - 2) Put into practice a method for analyzing 2D shapes: from skeleton detection to 3D shape reconstruction.
-

Pre-requisites

A good knowledge of linear algebra, optimization, and probability will facilitate understanding of this course.

Useful info

Place

- Toulouse

Elective Course: Advanced Study in IATI



ECTS

 10 credits



Component

 École Nationale

 Supérieure

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 d'Informatique

 d'Hydraulique

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In brief

- > **Ametys Code:** M34HLE8M
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Advanced Study SIA	Choix				
SIGNAL ADVANCED METHODS	UE				5 credits
Signal representation and analysis	Matière				
Optimal filtering	Matière				
Multivariate analysis	Matière				
Inverse problems	Matière				
AI FUNDAMENTALS	UE				5 credits
Information Theory	Matière				
Introduction to Deep Learning	Matière				
Statistics - advanced methods	Matière				
Computational statistics	Matière				
Advanced Study TSE	Choix				
SIGNAL ADVANCED METHODS	UE				5 credits
Signal representation and analysis	Matière				
Optimal filtering	Matière				
Multivariate analysis	Matière				
AI INTRODUCTION	UE				5 credits
Introduction to Deep Learning	Matière				
General AI integration: first hardware integration	Matière				

Advanced Study SIA



Component

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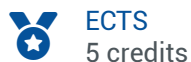
In brief

- **Ametys Code:** M34HLECN
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
SIGNAL ADVANCED METHODS	UE				5 credits
Signal representation and analysis	Matière				
Optimal filtering	Matière				
Multivariate analysis	Matière				
Inverse problems	Matière				
AI FUNDAMENTALS	UE				5 credits
Information Theory	Matière				
Introduction to Deep Learning	Matière				
Statistics - advanced methods	Matière				
Computational statistics	Matière				

SIGNAL ADVANCED METHODS



In brief

- **Ametys Code:** M34HLEGK
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Signal representation and analysis	Matière				
Optimal filtering	Matière				
Multivariate analysis	Matière				
Inverse problems	Matière				

Signal representation and analysis



Component

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In brief

- **Ametys Code:** M34HLEMK
- **Open to exchange students:** Yes

Presentation

Objectives

Placing oneself in a transformed space allows one to highlight particular characteristics of the signal. The aim of the course is to present the diversity of tools for representing deterministic or random signals and their use in decision-making, analysis, compression, etc.

Description

- Different classes of signals
- Review of classic representations (correlations, spectral densities)
- Decomposition based on functions (Fourier, Haar, Hadamard, etc.)
- Time-frequency representations (sliding Fourier transform, energy distributions - Cohen class: Wigner-Ville, etc.)

- Time-scale representations (continuous wavelet transform, orthogonal wavelet decompositions, bi-orthogonal wavelet decompositions, frames, multiresolution analysis).

Pre-requisites

- N5EE01A - Integration
- N5EE01B - Complex variables
- N6EE02A - Signal processing
- N6EE02B - Digital signal processing

Optimal filtering



Component

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Télécommunications

In brief

- **Ametys Code:** M34HLERZ
- **Open to exchange students:** Yes

Presentation

Objectives

Understand optimal filtering solutions and know how to implement adaptive versions.

Description

- The different problems addressed: identification, inversion, noise cancellation, prediction
- Wiener optimal filter
- Stochastic gradient algorithm
- Optimal filter in the least squares sense
- Recursive least squares algorithm
- Kalman algorithm

Pre-requisites

- N5EE01C - Probabilities
- N6EE01A - Differential calculus and optimization
- N6EE02A - Signal processing
- N6EE02B - Digital signal processing

Multivariate analysis



Component

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In brief

- **Ametys Code:** M34HLEYQ
- **Open to exchange students:** Yes

Presentation

Objectives

The objective of this course is to introduce the basic techniques for quantitative analysis of multivariate data, with a particular focus on techniques useful for signal processing and machine learning. The methods that will be of interest to us in this context are both statistical and algebraic in nature.

By the end of the course, students will be able to explain the principles of the techniques covered, distinguish between them, apply them in practice, and choose the one that is appropriate for a given application.

Description

The initial part of the course includes a review of linear algebra (spectral decomposition, singular value decomposition) and probability and statistics (random vector, covariance matrix, empirical moments), as well as an introduction to the problem of low-rank approximation of a matrix. Next, we give a statistical formulation of the principal component analysis (PCA) technique, and then we study its properties and practical aspects related to its use. Finally, we introduce the independent component analysis (ICA) problem, and then describe some classical approaches (kurtosis maximization, negentropy maximization, mutual information minimization) and the basic algorithms that derive from them.

Pre-requisites

- Linear algebra and matrix analysis (spectral decomposition, singular value decomposition, Frobenius and spectral norms of a matrix)
- Probability and statistics (random vectors, their theoretical and empirical moments)

Inverse problems



Component

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In brief

- **Ametys Code:** M34HLF5J
- **Open to exchange students:** Yes

Presentation

Objectives

Know how to identify an inverse problem, understand the concept of ill-posed or ill-conditioned problems, understand the importance of regularization, master a few regularization methods, formulate regularization in a Bayesian context.

Description

Course outline

- Introductory example: deconvolution of sparse signals
- # Direct modeling
- # Naive inversion and least squares solutions
- # Sparse regression (MP, OMP)
- Characterization of inverse problems

- # Ill-posed problems
 - # Conditioning
 - # SVD-based solutions
 - Regularization/penalization
 - # Penalized and constrained formulations
 - # Tikhonov regularizations
 - # Parsimonious regularizations
 - Probabilistic formulation
 - # Inversion and estimation
 - # Linear Gaussian case
 - # Bayesian regularization
-

Pre-requisites

- (Digital) signal processing
- Linear algebra
- Probability
- Statistics (estimation)
- Advanced statistics (Bayesian estimation)

AI FUNDAMENTALS



ECTS
5 credits



Component
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Télécommunications

In brief

- **Ametys Code:** M34HLFTA
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Information Theory	Matière				
Introduction to Deep Learning	Matière				
Statistics - advanced methods	Matière				
Computational statistics	Matière				

Information Theory



Component

École Nationale
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Télécommunications

In brief

- **Ametys Code:** M34HLFZM
- **Open to exchange students:** Yes

Presentation

Objectives

Introduce the fundamental concepts of information theory, namely entropy, relative entropy, and mutual information.

Pre-requisites

probability

Introduction to Deep Learning



Component

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Télécommunications

In brief

- **Ametys Code:** M34HLG5B
- **Open to exchange students:** Yes

Presentation

Objectives

This course aims to introduce the fundamental concepts underlying machine learning, and more specifically deep learning. A second objective is to familiarize students with the Python libraries numpy and pytorch, which are widely used in academia and industry for machine learning.

Description

This subject is taught in the form of a lecture (CM) followed by three practical sessions (CTP) combining the presentation of concepts with practical examples on Jupyter. The lecture provides the basics for understanding machine learning (data, assumptions, statistical risk, empirical risk, loss function, etc.), and in particular the supervised learning paradigm, which is the focus of this course. The first CTP session then introduces numpy with the implementation of a classic layer (MLP) of a deep learning model (neural network) and its training. The second CTP focuses on training a deep model, regularization techniques, and their link to the model's generalization capacity. In the third CTP, we introduce convolutional neural networks (CNNs) and their motivation, as well as their implementation in pytorch.

Pre-requisites

- Linear algebra and matrix analysis (derivatives of a multivariate function)
- Optimization (gradient descent)
- Probability and statistics
- Signal processing (convolution, linear filters)
- Python programming

Statistics - advanced methods



Component

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Télécommunications

In brief

- **Ametys Code:** M34HLGBT
- **Open to exchange students:** Yes

Presentation

Objectives

Introduce advanced statistical modeling and methods.

Description

Course outline

- Markov chains
- Bayesian estimation
- Regression models

Pre-requisites

- Linear algebra

- Probability
- Statistics (maximum likelihood estimation)

Computational statistics



Component

École Nationale
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Télécommunications

In brief

- **Ametys Code:** M34HLGGK
- **Open to exchange students:** Yes

Presentation

Objectives

Introduce the main estimation algorithms.

Description

Course outline

- Expectation-maximization algorithm
- Monte Carlo algorithms
- Variational approximation

Pre-requisites

- Linear algebra

- Probability
- Statistics (estimation)
- Advanced statistics (Markov chains, Bayesian estimation)

Advanced Study TSE



Component

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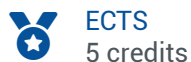
In brief

- **Ametys Code:** M34HLHRO
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
SIGNAL ADVANCED METHODS	UE				5 credits
Signal representation and analysis	Matière				
Optimal filtering	Matière				
Multivariate analysis	Matière				
AI INTRODUCTION	UE				5 credits
Introduction to Deep Learning	Matière				
General AI integration: first hardware integration	Matière				

SIGNAL ADVANCED METHODS



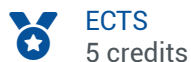
In brief

- **Ametys Code:** M34HLHWD
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Signal representation and analysis	Matière				
Optimal filtering	Matière				
Multivariate analysis	Matière				

AI INTRODUCTION



Component
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HLIJQ
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Introduction to Deep Learning	Matière				
General AI integration: first hardware integration	Matière				

General AI integration: first hardware integration



Component

École Nationale
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d'Électronique
d'Informatique
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et des
Télécommunications

In brief

- **Ametys Code:** M34HLINC
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand the history of Artificial Intelligence (AI) and the reasons for its rise.
- Understand the different categories of AI, including machine learning and deep learning.
- Be aware of the limitations of AI and the challenges of development (particularly those related to databases).
- Understand different AI algorithms, along with their advantages and disadvantages.
- Develop a consistent and comprehensive database for the development of an embedded model (prepared in the previous semester).

Description

The course consists of 7 hours of lectures and 21 hours of project work. Assessment is based on a project report. The lectures present the concepts outlined in the learning objectives from a theoretical perspective. The project highlights the challenges of

creating a database, even for a relatively simple application. It also provides hands-on experience with tools and hardware for developing embedded AI models on constrained hardware.

Pre-requisites

For the project, proficiency in C for embedded systems (μ C) and Python is required.

Semestre 9 - Systems Integration (INSYS)



ECTS
30 credits



Component
École Nationale
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d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M8FQG5ZK
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
ANALOG ELECTRONIC SYSTEMS IN RADIOFREQUENCIES	UE				5 credits
Optoelectronic Components and Circuits	Matière				
Filter Synthesis	Matière				
Integrated photonics	Matière				
Internet of Things	Matière				
DIGITAL SYSTEMS	UE				5 credits
Synthesis strategy	Matière				
EMC for integrated circuits	Matière				
System on Chip	Matière				
ANALOG AND DIGITAL SYSTEMS	UE				5 credits
ADC and DAC	Matière				
Space Embedded Systems Conferences	Matière				
Integration of instrumentation chains	Matière				
Reliability of embedded systems	Matière				
1st ELECTIVE TEACHING UNIT	UE				5 credits
ADVANCED DIGITAL ELECTRONICS	UE				5 credits
FPGA system design for signal processing	Matière				
Circuit testing and fault simulation	Matière				
ADVANCED ANALOG ELECTRONICS	UE				5 credits
Introduction to Cadence Layout XL / Spectrum	Matière				
Analog ASIC project	Matière				
2nd ELECTIVE TEACHING UNIT	UE				5 credits
POWER MANAGEMENT	UE				5 credits
Microprocessor Power Supply	Matière				
MOSFET Driver Circuits	Matière				
EMC for SMPS	Matière				
FEM Modeling of Integrated passive filters	Matière				
ADVANCED RADIOFREQUENCY ELECTRONICS	UE				5 credits
RF equipment	Matière				
MMIC	Matière				
MEMS	Matière				
SOFT AND HUMAN SKILLS 3EA S9	UE				5 credits
Professional English-LV1-Semestre 9	Bloc				
Anglais Scientifique	Matière				
Choix 2 Anglais Professionnel - 3A	Choix				
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				
CV Entretiens(3EA)	Matière				
Recherche doc.(3EA)	Matière				
CHOIX SHS 3EA S9	Choix				
Entrepreneurship Project	Matière				
Corporate Project and social responsibility	Matière				

ANALOG ELECTRONIC SYSTEMS IN RADIOFREQUENCIES



ECTS
5 credits



Component
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d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HPMMF
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Optoelectronic Components and Circuits	Matière				
Filter Synthesis	Matière				
Integrated photonics	Matière				
Internet of Things	Matière				

Optoelectronic Components and Circuits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE04B
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the drivers behind the technological choices that enable the creation of high-speed fiber optic communication systems.

Be able to design a high-frequency fiber optic communication system.

Analyze the performance limits of fiber optic communication systems and identify the limiting factors.

Description

This course presents the latest developments in optoelectronic systems in the high-frequency domain, with a focus on short-distance telecommunications applications such as the 10Gb Ethernet standard. The modeling of the essential components of these systems: laser diodes, photodiodes, electro-optical modulators, etc. is presented in detail. The design of circuits dedicated to the high-frequency modulation of laser diodes and the amplification of photodetected signals allows for a system-level approach to the design of a communication system in the GHz range.

Pre-requisites

Knowledge of semiconductor components for optics

Knowledge of fiber optic telecommunications (structure of an optical fiber, attenuation, and dispersion).

Basic knowledge of noise in electronics

Filter Synthesis



Component
École Nationale
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d'Électronique

In brief

- **Ametys Code:** N9EE06C
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of this project, students will be able to:

- define filter specifications that meet the overall constraints of a microwave multiplexer
- establish and analyze the coupling matrix associated with each filter
- define and develop the filter topology that meets the specifications
- determine and simulate the overall architecture of the multiplexer.
- analyze performance and propose design and correction methods.

Description

This course is a project-based learning experience in microwave multiplexer design based on the determination of coupling matrices.

Pre-requisites

Course: "Analog Filtering" - 2nd year EEEA, Electronics track

ADS lab, N7EE06D - 2nd year EEEA, Electronics track

Integrated photonics



Component

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In brief

- **Ametys Code:** M34HPMTN
- **Open to exchange students:** Yes

Presentation

Objectives

By the end of this course, students will be able to:

- Understand the fundamental principles of guided light propagation in integrated media.
- Analyze and design the basic structures of integrated photonics (edge couplers, grating couplers, optical filters, Mach-Zehnder interferometers, microring resonators, arrayed waveguide grating waveguide networks, modulators, etc.).
- Use advanced simulation tools (EME, FDTD 2D, 3D) for modeling and optimizing integrated photonic components.
- Design an integrated refractometer for biomolecule detection using appropriate simulation software.
- Interpret and analyze simulation results to evaluate the performance of the designed devices.
- Write a detailed design report presenting the methodology, design choices, and performance of the device.

Description

1. Introduction to integrated photonics

Review of the basic principles of guided optics: propagation equations, guided modes, dispersion.

Concept of effective index, group index.

Comparison of the main integrated photonics platforms (silicon, SiN, etc.).

Comparison of optical fiber and integrated photonics

2. Fundamental structures and passive components

Optical coupling: edge coupler, grating coupler. Passive structure: Single optical waveguide, curved optical waveguide, Y-splitter, multi-mode interferometer, directional coupler.

Interferometers and optical filters: Mach-Zehnder interferometer (MZI), resonant rings (microring resonator), waveguide gratings (AWG).

3. Active components and modulators

Principles of optical modulators: electro-optical, thermo-optical, and acousto-optical modulators.

Opto-electronic detection and conversion.

4. Simulation tools and techniques

Introduction to simulation methods: Eigenmode Expansion (EME) and Finite-Difference Time-Domain (FDTD) methods.

Getting started with simulation software and parameterization of photonic structures.

5. Design office: design of an integrated refractometer

Project specifications: detection of biomolecules via a change in refractive index.

Design and optimization of the structure using simulation software.

Performance analysis and validation of the device.

Drafting of a detailed design report.

Pre-requisites

Electromagnetism

Guided propagation

Optoelectronics

Optoelectronics lab

Internet of Things



Component
École Nationale
Supérieure
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d'Électronique

In brief

- **Ametys Code:** N9EE06D
- **Open to exchange students:** Yes

Presentation

Objectives

To gain a clear understanding of the role of electronic systems in IoT. To become familiar with the ISO/IEC 14443 standard as an illustration of IoT, and its requirements for the design and implementation of its physical layer.

Description

- 1) General information on IoT: History and evolution – architecture – applications
- 2) Data in IoT: Encoding – Modulation – Data integrity – Data security – choices based on applications
- 3) Examples of IoT systems: NFC (Frequency/range/application – NFC standards – Example ISO/IEC14443 – Solutions offered by NXP)
- 4) Physical layer and examples of electronic design: inductive coupling circuit for HF applications – power supply issues for passive tags – antenna adaptation – power balance

Pre-requisites

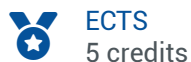
Analog/digital/radio frequency electronic signals

Signal coding and modulation

Analog and radio frequency circuits

Electromagnetism/S parameters/Antenna adaptation

DIGITAL SYSTEMS



In brief

- **Ametys Code:** M34HP010
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Synthesis strategy	Matière				
EMC for integrated circuits	Matière				
System on Chip	Matière				

Synthesis strategy



Component
École Nationale
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d'Électronique

In brief

- **Ametys Code:** N9EE05A
- **Open to exchange students:** Yes

Presentation

Objectives

By the end of this course, students will be able to:

- Understand the fundamental principles of microelectronics and the key stages in the manufacture of integrated circuits (analog, digital, mixed) and their applications.
- Master the fundamental concepts and structures of the VHDL language for hardware description.
- Write, simulate, and implement modules in VHDL, taking hardware constraints into account.
- Understand the direct link between code and hardware.
- Understand the concepts of timing, metastability, and asynchronism.
- Understand techniques for managing asynchronism.
- Design a test bench and perform simulations/debugging to verify circuit functionality.
- Perform circuit synthesis and routing, analyzing performance and optimizing architecture according to requirements.
- Understand power/performance/target trade-offs and digital circuit optimization strategies.

Description

Part 1: Overview of the world of microelectronics

Introduction to microelectronics

Basic principles and role in the electronics industry.

Historical evolution and technological advances.

Presentation of key materials and components

Wafers: manufacturing and role in circuit design.

Masks and packages: manufacturing processes and impact on performance.

Types of integrated circuits: analog, digital, mixed (examples and applications).

Presentation of basic VHDL structures and constraints.

Project presentation.

Part 2: Introduction to and in-depth study of the VHDL language

Practical work 1 – Introduction to basic structures (4 hours)

Understanding and modeling key components (RAM, ROM, DSP, etc.).

Use of generic structures (generics, constants, complex buses).

TP2 – Simulation and implementation (4 hours)

Creation and validation of a testbench.

Simulation and debugging of digital circuits.

Introduction to timing concepts (setup/hold) and associated constraints.

TP3 – Synthesis and optimization (4 hours)

Synthesis and routing processes on FPGA/ASIC.

Performance analysis and optimization strategies.

Power/performance/target trade-offs: partitioning, parallelization, resource sharing.

Part 3: Concepts of timing, metastability, and asynchronism

Practical work 4 – Timing, metastability, and asynchronism (4 hours)

Data flow constraints and asynchronism

Concepts of timing violations and metastability

Techniques for managing asynchronism

EMC for integrated circuits



Component

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In brief

- **Ametys Code:** M34HPOT5
- **Open to exchange students:** Yes

Presentation

Objectives

By the end of this course, students will be able to:

- Understand the fundamental principles of electromagnetic compatibility (EMC) as applied to integrated circuits.
- Identify and analyze electromagnetic coupling mechanisms in integrated circuits.
- Master the basic units and concepts associated with EMC measurements.
- Interpret the use of frequency bands according to applications and regulations.
- Analyze signals in the time domain (square wave theory) and in the frequency domain (power measurement).
- Classify integrated circuit pins according to EMC requirements and compliance standards.
- Understand the main EMC standards for the automotive industry (IEC, ISO) and their specifications.
- Understand the certification process and compliance testing associated with integrated circuits.

Description

1. Introduction to EMC

Definition and challenges of electromagnetic compatibility.

Context of application to integrated circuits.

2. Electromagnetic coupling mechanisms

Capacitive, inductive, radiated, and conduction coupling.

Impact of coupling mechanisms on the behavior of integrated circuits.

3. Fundamental concepts and units in EMC

Quantities and units used in EMC.

Electromagnetic compatibility measurements.

4. Use of frequency bands

Regulations and frequency band allocations.

Applications and constraints related to frequency bands in EMC.

5. Analysis of signals in EMC

Time domain: square wave theory and impact on EMC.

Frequency domain: power measurement theory and implications in EMC.

6. Pin classification and integrated circuit compliance

Pin typology and impact on EMC.

Compliance classes and specific requirements.

7. EMC standards and regulations for the automotive industry

Introduction to EMC standards applied to automotive integrated circuits.

Main IEC and ISO standards.

Generic test specifications for integrated circuits (Generic IC EMC Test Specification v1.2).

8. Certification process and compliance testing

Classification of tests and compliance levels.

Acceptable EMC limits and thresholds for the automotive industry.

Proliferation of standards and their evolution.

System on Chip



Component
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d'Électronique

In brief

- **Ametys Code:** N9EE05C
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of the lectures, third-year students in the InSys program in the EEEA department will be able to:

- define precisely what a SoC is;
- explain the advantages of these circuits
- compare the relevance of choosing a SoC over an ASIC.

At the end of the project sessions, third-year students in the InSys program in the EEEA department will be able :

- generate an SoC and integrate it into a Xilinx Zynq FPGA circuit;
- test different function development techniques on this family of circuits (hardware or software)
- imagine and produce audio functions that can be implemented on the circuit, having chosen the most efficient technique.

Description

The System-On-Chip course consists of two lectures and around ten project sessions.

The lectures provide a detailed description of what a System-On-Chip is, its technological and economic advantages, its limitations and challenges, and why these circuits constitute a rapidly expanding market. In particular, the concepts of reuse, IP, and hardware/software co-development are explained in detail.

The project sessions put these concepts into practice by designing an audio effects device in the Xilinx Vivado development environment on a Zynq development board. During the first sessions, students develop the Zynq hardware configuration and

program the microcontroller in C language to briefly control an audio codec. They then develop and add audio effects of their choice to this basic configuration, in C or VHDL.

The assessment consists of two parts: a demonstration of the circuit and the effects developed during the session, and a report, in English, based on the model of a device user manual.

Pre-requisites

Basic knowledge of microelectronics and embedded systems, in particular:

- Silicon technology
- Microprocessor architecture
- Timing analysis
- * Basic experience with the Xilinx Vivado development environment
- * Basic experience with VHDL and C programming languages

ANALOG AND DIGITAL SYSTEMS



ECTS
5 credits



Component
École Nationale
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d'Électronique
d'Informatique
d'Hydraulique
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Télécommunications

In brief

- **Ametys Code:** M34HPPS9
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
ADC and DAC	Matière				
Space Embedded Systems Conferences	Matière				
Integration of instrumentation chains	Matière				
Reliability of embedded systems	Matière				

ADC and DAC



Component
École Nationale
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d'Électronique

In brief

- **Ametys Code:** N9EE06B
- **Open to exchange students:** Yes

Presentation

Objectives

- Design an analog-to-digital converter using CMOS technology.
- Be able to characterize the converter's performance.
- Be familiar with the different converter architectures and their performance.

Description

- The different analog-to-digital converter architectures are presented, along with the parameters used to characterize the converters.
- The diagram of a CMOS technology converter is designed to meet specific specifications and verified by simulation.

Pre-requisites

- Circuit basics
- Transistor circuits
- Operational amplifier circuits

Analog integrated circuits

Space Embedded Systems Conferences



Component

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Télécommunications

In brief

- **Ametys Code:** M34HOTV8
- **Open to exchange students:** Yes

Presentation

Objectives

Upon completion of this course, students will be able to:

Understand the challenges and constraints of spaceborne systems and electronic technologies used in the aerospace industry.

Understand the characteristics of antennas for SmallSats, their specific features, and future trends.

Explore the challenges of sustainable space, including debris management, regulation, and risk mitigation strategies in orbit.

Identify the effects of radiation on avionics and space equipment and understand strategies for protecting and ensuring the reliability of electronic systems.

Description

This course is taught by several external speakers on the topic of spaceborne systems. The topics are diverse and may include

- sustainable space
- antennas for smallsats

- satellite-borne microwave technologies
- radiative effects on avionics equipment

Pre-requisites

None

Integration of instrumentation chains



Component
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d'Électronique

In brief

- **Ametys Code:** N9EE07A
- **Open to exchange students:** Yes

Presentation

Objectives

- Design an analog CMOS interface for a MEMS accelerometer.
- Understand fully differential techniques for operational amplifiers.
- Design common mode control architectures for fully differential amplifiers.
- Understand noise reduction techniques such as chopping and auto-zeroing.
- Learn how to write a design report.

Description

The aim of this course is to discover CMOS design techniques used for the analog front end of sensors: low noise, differential, leakage current, etc.

During this course, students will design and simulate a CMOS circuit to interface a MEMS accelerometer by implementing a fully differential amplifier with integrated common mode control and a chopping system.

Pre-requisites

Circuit basics

Transistor circuits

Operational amplifier circuits

Analog integrated circuits

Amplification classes

Reliability of embedded systems



Component

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In brief

- **Ametys Code:** M34HPPYB
- **Open to exchange students:** Yes

Presentation

Objectives

By the end of this course, students will be able to:

- Understand the fundamental principles of functional safety and its importance in critical systems.
- Identify and analyze different categories of failures (systematic and random) and the associated fault models.
- Master risk management approaches applied to embedded systems, particularly in the automotive field.
- Understand the ISO 26262 standard and its requirements for functional safety.
- Perform safety analyses at the system and hardware component levels.
- Implement design strategies to achieve the safety objectives defined by ASIL integrity levels.
- Perform specific safety analyses such as FTA (Fault Tree Analysis), FMEDA (Failure Modes, Effects and Diagnostic Analysis) and DFA (Dependent Failure Analysis).

Description

1- Introduction to functional safety

Definition and importance of functional safety.

History and evolution of safety standards.

General approach to risk management and classification of failures (systematic vs. random).

Risk management in the automotive industry.

Concepts of safety goals and safety integrity levels (ASIL).

Introduction to ISO 26262.

2 - Awareness of functional safety

Overview of ISO 26262 and structure of the standard.

Conceptual phase

Definition of items.

Risk analysis and HARA (Hazard Analysis and Risk Assessment).

Development of the Functional Safety Concept (FSC).

System-level development

Definition of the Technical Safety Concept (TSC).

ASIL decomposition and design decisions.

System-level safety analysis methods.

Testing and integration into the development cycle.

3- Hardware development and safety analyses

Hardware life cycle and specific safety requirements.

Development of the Hardware Safety Concept and associated safety mechanisms.

Hardware safety analysis techniques:

FTA (Fault Tree Analysis): fault tree.

DFA (Dependent Failure Analysis): analysis of dependent faults.

Calculation of failure rate. FMEDA (Failure Modes, Effects, and Diagnostic Analysis): study of failure modes and diagnostic coverage.

Specific constraints for semiconductors in the automotive industry.

1st ELECTIVE TEACHING UNIT



ECTS
5 credits



Component
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Semester
Automne

In brief

- > **AmetyS Code:** N9EEAX1
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
ADVANCED DIGITAL ELECTRONICS	UE				5 credits
FPGA system design for signal processing	Matière				
Circuit testing and fault simulation	Matière				
ADVANCED ANALOG ELECTRONICS	UE				5 credits
Introduction to Cadence Layout XL / Spectrum	Matière				
Analog ASIC project	Matière				

ADVANCED DIGITAL ELECTRONICS



ECTS
5 credits



Component
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Semester
Automne

In brief

- > **Ametys Code:** N9EE08
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
FPGA system design for signal processing	Matière				
Circuit testing and fault simulation	Matière				

FPGA system design for signal processing



Component
École Nationale
Supérieure
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d'Électronique

In brief

- **Ametys Code:** N9EE08A
- **Open to exchange students:** Yes

Presentation

Objectives

Learn how to use a high-level synthesis tool to design signal processing functions for FPGAs.

Learn how to define and optimize a signal processing system architecture (TS function + interfaces and memory management).

Test and optimize the system on an FPGA board

Description

In this course, students take on the role of an engineer working for Thales Alenia Space, tasked with developing and implementing a spectrum analyzer on an FPGA. They must complete the following tasks:

- Analyze signal processing system architecture
 - Create IP using high-level synthesis in C++ (HLS)
 - Coding and synthesis of the architecture and IP in VHDL
 - Verification
 - Implementation on FPGA
 - Testing on board
-

Pre-requisites

Logic system design (UE N5EE03)

Digital electronics (UE N7EE08)

Digital systems architecture (N8EE03)

Circuit testing and fault simulation



Component
École Nationale
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d'Électronique

In brief

- **Ametys Code:** N9EE08B
- **Open to exchange students:** Yes

Presentation

Objectives

By the end of this course, students will be able to:

- Understand the destructive mechanisms affecting electronic circuits and the associated protection techniques.
- Master the fundamental concepts of integrated circuit reliability.
- Analyze and model faults in logic circuits and memories.
- Design and apply test generation strategies to detect faults in logic, sequential, and memory circuits.
- Implement design for test (DFT) methodologies to improve circuit testability.
- Explore advanced testing techniques for analog, mixed-signal, and RF circuits.
- Use simulation tools to evaluate the robustness and reliability of electronic circuits.

Description

1. Introduction

Presentation of the challenges of testing and fault simulation.

Importance of functional safety in modern integrated circuits.

2. Basic Concepts

Destructive mechanisms: wear, aging, physical failures.

Protection techniques: redundancy, circuit hardening.

Functional safety: reliability, availability, maintainability.

3. Logic circuit testing

Faults and patterns: classic faults (stuck-at, transition, delay, etc.), fault patterns.

Test generation: ATPG (Automatic Test Pattern Generation), fault coverage.

Sequential circuits: testing registers and automata.

Memory testing: specific failures, memory testing algorithms (March, BIST).

4. Design for Testability (DFT)

Principle: improving testability from the circuit design stage.

Generic techniques: scan chains, structured testability.

Built-in Test (BIT): principles and applications.

Built-in Self-Test (BIST): architectures and implementation.

5. Testing analog, mixed-signal, and RF circuits

Specific features: differences from digital circuit testing.

Test methods: parametric testing, functional testing.

DFT for analog and RF circuits: strategies and challenges.

ADVANCED ANALOG ELECTRONICS



ECTS
5 credits



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Semester
Automne

In brief

- **Ametys Code:** N9EE07
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Introduction to Cadence Layout XL / Spectrum	Matière				
Analog ASIC project	Matière				

Introduction to Cadence Layout XL / Spectrum



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE06A
- **Open to exchange students:** Yes

Presentation

Objectives

Learn how to design the layout of an integrated circuit using design rules.

Learn how to use LVS verification tools.

Learn how to extract parasitic elements from a circuit.

Learn how to simulate the post-layout version of a circuit.

Learn how to analyze the comparison between the post-layout circuit and the ideal circuit.

Description

During this introductory course, participants will learn how to use the professional integrated circuit design software CADENCE with a CMOS operational amplifier in 0.35µm technology.

The layout must be designed in accordance with design rules. DRC/LVS verification tools and post-layout simulations that take into account mask-related parasitics are also covered.

Analog ASIC project



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE07B
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of the analog integrated circuit design project, students will be able to structure and compose a sophisticated integrated circuit, demonstrating their mastery of the design stages when the specified performance of the integrated circuit is achieved.

Description

The project involves discovering, understanding, and mastering the various stages of designing a complex analog integrated circuit. In this context, Virtuoso® Schematic & Layout design tools are used to design a linear regulator including a bandgap voltage reference (5V/2V 10mA, BW >1MHz, PSRR 50dB) in sub-micron CMOS technology. After two lectures providing additional information to supplement the basic concepts acquired in L3 and M1, a project spread over N practical sessions will follow the design stages from the specifications to the drawing of the circuit masks using the Cadence® analog design flow environment. The main stages are: a bibliographic search of existing topologies, a design phase at the transistor level of the analog blocks that make up the circuit, a "worst-case" validation by parametric variation of the models of the components used, and the creation and design of the masks in accordance with the pairing rules.

The learning method used for this subject is Problem-Based Learning, which gives students a great deal of creative freedom when designing their circuits. Access to online documentation (open libraries, IEEE scientific articles, for example) provides the material needed to explore various circuit architectures that can meet the project's requirements.

Pre-requisites

Knowledge of the operating principles of bipolar and silicon MOSFET transistors (parameters, technology, MOSFET/BJT) as well as the basics of analog circuit design (common emitter/collector stage assembly, differential stage, push-pull circuit, etc.).

2nd ELECTIVE TEACHING UNIT



ECTS

 5 credits



Component

 École Nationale

 Supérieure

 d'Électrotechnique

 d'Électronique

 d'Informatique

 d'Hydraulique

 et des

 Télécommunications



Semester

 Automne

In brief

- > **Ametys Code:** N9EEAX2
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
POWER MANAGEMENT	UE				5 credits
Microprocessor Power Supply	Matière				
MOSFET Driver Circuits	Matière				
EMC for SMPS	Matière				
FEM Modeling of Integrated passive filters	Matière				
ADVANCED RADIOFREQUENCY ELECTRONICS	UE				5 credits
RF equipment	Matière				
MMIC	Matière				
MEMS	Matière				

POWER MANAGEMENT



ECTS
5 credits



Component
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Semester
Automne

In brief

- **Ametys Code:** N9EE09
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Microprocessor Power Supply	Matière				
MOSFET Driver Circuits	Matière				
EMC for SMPS	Matière				
FEM Modeling of Integrated passive filters	Matière				

Microprocessor Power Supply



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE09A
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of the training course on microprocessor power supply design, M2-level students will be able to size and simulate a 12V/0.8V 100A multiphase converter, demonstrating their mastery of the design stages when the performance defined in the specifications is achieved.

Description

Course outline:

Introduction

- Advantages of using switching power supply
- Buck converter
 - Principle of operation
 - Continuous and Discontinuous Current Modes (CCM, DCM)
 - Losses and efficiency
 - Overview of closed-loop stability study

Boost converter

- Principle of operation
- Continuous and Discontinuous Current Modes
- Overview of closed-loop stability study

Multiphase converter

- Principle of operation
- Transient response performances and filter reduction
- DC-DC Converter Regulation Loop Analysis
- Theoretical analysis of switched systems using state variables
- Different types of control loops
- Considerations for the controller design
 - Buck: Voltage and Voltage/Current loop cases
 - Boost & Buck-Boost: Voltage and Voltage/Current loop cases

Pre-requisites

Knowledge of the operating principles of bipolar and silicon MOSFET transistors, as well as the basics of analog circuit design (Kirchhoff's current/voltage laws, passive dipoles, op-amp-based circuits, etc.).

MOSFET Driver Circuits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE09B
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of the training course on the design of driver circuits dedicated to power transistor control, M2-level students will be able to size, control, and simulate an inverter arm, demonstrating their mastery of the various stages of power transistor switching when EMC and energy efficiency performance targets are met.

Description

Course outline:

- Part 1: Introduction to power switches
- Part 2: Driver design
- Part 3: Drivers & power supply topologies

EMC for SMPS



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE09C
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of the training course on EMC in switching power supplies, M2-level students will be able to determine the nature of the various sources of interference within electronic devices and make the best choices in terms of packaging, 3D assembly, and loss/EMC trade-offs, demonstrating their mastery of the concepts related to conducted and radiated emissions when the harmonic spectrum of the generated signals complies with industry standards.

Description

Course outline:

- Technology limits
 - Silicon components (MOSFET, Diode)
 - Passive devices (Inductance, Capacitance)
 - EMC
 - DC/DC converter Spectral analysis
 - EMI filter design
 - Board and IC Layout: rules of thumb
-

Pre-requisites

Knowledge of the operating principles of bipolar and silicon MOSFET transistors, as well as the basics of analog circuit design (Kirchhoff's current/voltage laws, passive dipoles, op-amp-based circuits, etc.) and the "MOSFET Driver Circuits" course.

FEM Modeling of Integrated passive filters



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE09D
- **Open to exchange students:** Yes

Presentation

Objectives

The objective is to gain a more precise understanding of the electromagnetic functioning of these inductors and to define a methodology for virtually identifying the elements of the equivalent electrical circuit defined in the course.

Description

Students are asked to carry out a project whose objective is to simulate, using the finite element method and Comsol Multiphysics software, the electromagnetic behavior of an inductor coupled to two phases in order to identify the parameters of the classic equivalent electrical circuit. Knowledge of these parameters, as well as loss parameters, over a realistic frequency range, is necessary in order to then be able to electrically simulate the overall operation of the power supply.

ADVANCED RADIOFREQUENCY ELECTRONICS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

- > **Ametys Code:** N9EE10
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
RF equipment	Matière				
MMIC	Matière				
MEMS	Matière				

RF equipment



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE10A
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of this course, students will be able to:

- Implement design methods for complex telecommunications systems that must meet electrical performance criteria.
- Define a system architecture and analyze its performance.
- Develop equipment by applying RF integrated circuit design methods.

Description

Course by S. George, Thales Alenia Space:

General information about satellites:

Satellite missions

Telecommunications payload architecture:

Equipment

Technologies

Future developments: Flexible payloads

Impact on equipment and technologies

Application BE:

Development of satellite payload architecture using COTS (Components On The Shelf) components that must meet the following criteria: gain, noise figure, and linearity

Design of equipment (VGA: Voltage Gain Amplifier) using 12GHz MMIC technology.

MMIC



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE10B
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of this course, students will be able to:

- Determine amplifier architectures that meet their specifications.
- Implement integration technologies specific to the field of microwave MMICs.
- Understand the difficulties involved in integrating amplifiers.
- Comply with integrated technology implementation constraints.
- Analyze performance and propose design and correction methods adapted to the problem.
- Design an MMIC chip that meets all system, integration, and electrical performance constraints.

Description

Lecture 1: From Semiconductors to RF Transistors – Sébastien Delcourt – THALES ALENIA SPACE

Lecture 2: From transistors to MMICs – Sébastien Delcourt – THALES ALENIA SPACE

Lecture 3: MMIC design – Fabrice Delahaye – THALES ALENIA SPACE

Lecture 4: Case study: from antenna to MMIC – Fabrice Delahaye – THALES ALENIA SPACE

Project-based learning: Response to industrial specifications (LNA, LLA, or MLA)

Pre-requisites

Course N7EE06A "Active RF Circuits" – 2nd year EEEA, Electronics track
ADS lab, N7EE06D – 2nd year EEEA, Electronics track

MEMS



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE10C
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of this course, students will be able to:

- understand the techniques used to implement mobile objects
- understand the different stages of MEMS design and mechanical analysis
- dimension a MEMS that meets criteria for switching speed, switching voltage, and reliability.
- extract an electrical behavioral model of the MEMS
- use MEMS to design an original RF function with tunable electrical characteristics.

Description

MEMS: What are they?

Application of MEMS in the following fields:

Optics

Mechatronics

Medical

RF

Clean room technology concepts

Mechanical model of MEMS:

Static model

Dynamic model

RF modeling of MEMS

Example of a MEMS-RF design procedure

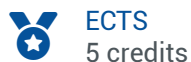
Application project: Design of a tunable RF system using a V-band (60GHz) MEMS

Implementation of an electromagnetic model of MEMS (HFSS)

Extraction of the electrical model (ADS) and application of a parametric model for the design of a tunable bandpass filter from 60GHz to 40 GHz.

Definition of a tunable function to be designed, implemented, and validated by simulation.

SOFT AND HUMAN SKILLS 3EA S9



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- > **Ametys Code:** N9EK02
- > **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Professional English-LV1-Semestre 9	Bloc				
Anglais Scientifique	Matière				
Choix 2 Anglais Professionnel - 3A	Choix				
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				
CV Entretiens(3EA)	Matière				
Recherche doc.(3EA)	Matière				
CHOIX SHS 3EA S9	Choix				
Entrepreneurship Project	Matière				
Corporate Project and social responsibility	Matière				

Professional English-LV1 -Semestre 9



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EK01A
- **Open to exchange students:** No

Presentation

Description

Develop your professional communication skills by performing common written and oral communication tasks in English.

List of courses

	Nature	CM	TD	TP	Crédits
Anglais Scientifique	Matière				
Choix 2 Anglais Professionnel - 3A	Choix				
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				

Anglais Scientifique



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EK01AA
- **Open to exchange students:** No

Presentation

Description

Specific teaching to improve scientific English.

Choix 2 Anglais Professionnel - 3A



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

> **Ametys Code:** N9EK01AX

List of courses

	Nature	CM	TD	TP	Crédits
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				

Anglais Clinique



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EK01AB
- **Open to exchange students:** No

Presentation

Description

Specific teaching to reach level B2.

Anglais de Cambridge ou Projet



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EK01AC
- **Open to exchange students:** No

Presentation

Description

Specific teaching to prepare for the Cambridge Proficiency exam or a project.

CV Entretiens(3EA)



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

> **Ametys Code:** N9EK01BF

Presentation

Objectives

Ils consistent à accompagner les étudiants pour les aider à :

- rédiger des écrits professionnels, CV et lettre de motivation, en utilisant les particularités des formats papier ou électronique, et de la communication synchrone et asynchrone et en répondant aux demandes des entreprises.
- développer les qualités en communication écrite et orale : réussir les entretiens de recrutement, maîtriser d'une façon harmonieuse les relations professionnelles (interculturalité, relations hiérarchiques, team building),
- convaincre et persuader lors d'entretiens de recrutement et jusqu'à la signature du contrat de travail,
- finaliser et optimiser le P.P.P (Projet Professionnel Personnel).

Description

- analyser et synthétiser efficacement de façon à mieux communiquer oralement et à l'écrit, à propos de thèmes suivants : réussir son entretien de recrutement en présentiel en distanciel, les speed net working, le marché de l'emploi, le développement des starts up les codes du recrutement, point sur les outils du recrutement, utilisation de LINKEDIN, négocier son contrat de travail, son salaire, l'intérêt de l'expatriation...

- apprendre à mieux se connaître (ses points faibles et ses points forts) afin de mieux communiquer.

METHODE

- apports théoriques, «Communication écrite, orale», et «Bien démarrer sa vie professionnelle»
- mise en situation, avec la présentation orale (diaporama) et écrite d'un sujet en lien avec le recrutement,
- connaissance de soi, pédagogie inversée, développement du leadership, accompagnement adapté.

EVALUATION DES ETUDIANTS

Elle portera sur la réalisation d'exercices concernant : la rédaction d'un CV et d'une lettre de motivation efficaces, des simulations d'entretiens de recrutement, des présentations écrites et orales à propos des thèmes précisés ci-dessus.

ORGANISATION DES COURS

Les cours « Insertion professionnelle » s'organisent ainsi, il y a un décloisonnement des enseignements, ils sont orientés vers la recherche de stage/emploi et la communication :

- des forums du recrutement et des carrières sont proposés,
- les cours et TD sont donnés durant le semestre 1 de l'année universitaire (bac +5), soit 8 heures.

Ce calendrier est ponctué d'échanges par e-mail et en face à face avec l'enseignante, en fonction des besoins de l'étudiants.

Recherche doc.(3EA)



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** N9EK01BG

CHOIX SHS 3EA S9



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** N9EK02X

List of courses

	Nature	CM	TD	TP	Crédits
Entrepreneurship Project	Matière				
Corporate Project and social responsibility	Matière				

Entrepreneurship Project



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EK01E
- **Open to exchange students:** No

Presentation

Description

Project aimed at developing entrepreneurial skills.

Corporate Project and social responsibility



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** N9EK01F

Semestre 9 - Communication Systems (SYSCOM)



ECTS
30 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M8FQJS02
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
APPLIED PHYSICS AND NUMERICAL METHODS	UE				5 credits
Electromagnetism and multiscale devices	Matière				
Multiphysics Models	Matière				
Electromagnetism and nanoelectronics	Matière				
Synthesis of High Frequency Equivalent Electrical Circuits	Matière				
HIGH FREQUENCY EMBEDDED SYSTEMS	UE				5 credits
Microwave and Optical Sensors	Matière				
HF optoelectronic components and circuits	Matière				
Internet of Things	Matière				
Passive high frequency devices in waveguide technology	Matière				
MICROWAVE CIRCUITS AND ELECTROMAGNETIC COMPATIBILITY	UE				5 credits
Antenna networks	Matière				
Space antennas	Matière				
Aeronautical EMC 1	Matière				
Space Embedded Systems Conferences	Matière				
Microwave power amplifiers	Matière				
Aeronautical EMC 2	Matière				
PROPAGATION PHENOMENA AND RADAR	UE				5 credits
Actual propagation of electromagnetic waves	Matière				
Electromagnetic diffraction analysis / Radar equipment	Matière				
Radar project	Matière				
ELECTIVE TEACHING UNIT	Choix				5 credits
ADVANCED RADIOFREQUENCY ELECTRONICS	UE				5 credits
RF equipment	Matière				
MMIC	Matière				
MEMS	Matière				
MODELING	UE				5 credits
Variational methods for solving partial differential equations of physics	Matière				
Integral methods	Matière				
Plasma physics and applications	Matière				
SOFT AND HUMAN SKILLS 3EA S9	UE				5 credits
Professional English-LV1-Semestre 9	Bloc				
Anglais Scientifique	Matière				
Choix 2 Anglais Professionnel - 3A	Choix				
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				
CV Entretiens(3EA)	Matière				
Recherche doc.(3EA)	Matière				
CHOIX SHS 3EA S9	Choix				
Entrepreneurship Project	Matière				
Corporate Project and social responsibility	Matière				

APPLIED PHYSICS AND NUMERICAL METHODS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOQN6
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Electromagnetism and multiscale devices	Matière				
Multiphysics Models	Matière				
Electromagnetism and nanoelectronics	Matière				
Synthesis of High Frequency Equivalent Electrical Circuits	Matière				

Electromagnetism and multiscale devices



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE14B
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the fundamental electromagnetic descriptors of multiscale structures - Know how to calculate and physically interpret the electromagnetic field in manufactured multiscale devices - Know how to calculate and physically interpret the electromagnetic field backscattered by natural multiscale structures

Description

- I- Length standard in electromagnetism
- II- Electromagnetic analysis of multiscale structures
 - II-1 Limitations of conventional numerical methods for electromagnetic analysis of multiscale structures
 - II-2 Iterative approaches for electromagnetic analysis of multiscale structures
 - II-3 Fundamental electromagnetic descriptors of multi-scale structures
- III- Application to the design of electromagnetic devices
 - III-1 Multi-band antennas
 - III-2 Miniature antennas
 - III-3 Multi-frequency selective surfaces
 - III-4 Selective microwave filters
 - III-5 Multi-band electromagnetic mirrors
 - III-6 Electromagnetic lattices

IV- Application to the analysis of electromagnetic diffraction from natural structures

IV-1 Back scattering from rough surfaces

IV-2 Back scattering from the sea surface

IV-3 Back scattering from vegetation cover

IV-4 Backscattering from porous rocks

VI- Technological prospects in the field of multi-scale device design and manufacture Multi-scale

Pre-requisites

The following subjects: Electromagnetic Diffraction Analysis (Apogee code N9EE14C) - Electromagnetic Radiation and Antennas (Apogee code N8EE26A) - Physical Analysis of Guiding Structures (Apogee code N8EE07E)

Multiphysics Models



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE11B
- **Open to exchange students:** Yes

Presentation

Objectives

Discover the challenges of multiphysics modeling; learn how to use multiphysics simulation software based on the finite element method; learn how to perform geometric modeling, physical description of media, choice of meshing strategies, definition of stationary, parametric, and frequency analyses, and finally data exploitation, including the deduction of global parameters using curvilinear, surface, or volume integrals.

Description

The module consists of two parts:

- a session presenting the issues of multiphysics modeling and numerical methods,
- BE sessions covering the learning of the COMSOL Multiphysics simulation software, ending with the design of a microwave applicator in a metal resonant cavity, and the simulation of microwave and thermal performance.

Pre-requisites

Basic elements of electromagnetism, electrostatics, microwave engineering, partial differential equations, linear equation systems, 1D/2D/3D integrations, vector analysis.

Electromagnetism and nanoelectronics



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE14D
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the theoretical basics for solving physics problems involving a classical (non-quantized) electromagnetic field and a charged particle – Understand the concept of probability waves and know how to relate it to the calculation of probabilities of physical events – Understand the basic principles governing the operation of a tunneling microscope and a magnetic resonance imager

Description

- I- Electromagnetism at the nanoscale
- II- Probability waves
 - II-1 Definition and initial developments
 - II-2 First principles of wave mechanics
 - II-3 Probability wave interference phenomena and uncertainty relations
 - II-4 Schrödinger equation for a charged particle in a classical harmonic electromagnetic field
- III- Charged particle in an electrostatic field
 - III-1 Potential barrier
 - III-1 Potential barrier
 - III-2 Tunneling effect
 - III-3 Potential well
- IV- Electromagnetic applications
 - IV-1 Electron microscopy

IV-2 Magnetic resonance imaging
IV-3 Nanoantennas
IV-4 "Quantum radar"
V-Prospect in nano-electromagnetism

Pre-requisites

The following subjects: Electromagnetic radiation and antennas (Apogée code N8EE26A) – Guided and free-space propagation (Apogée code N7EE09A1)

Synthesis of High Frequency Equivalent Electrical Circuits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOQUV
- **Open to exchange students:** Yes

Presentation

Objectives

Know how to determine the equivalent electrical circuit of any passive RF devices based on physical considerations and controlled approximations
Know how to physically analyze the properties of the electromagnetic field in any passive RF devices - Know how to use equivalent electrical circuits for the synthesis of RF functions

Description

I. Symbolic representation of modal sources of electromagnetic fields

I-1- Thevenin generator for modeling a modal electric field source

I-2- Norton generator for modeling a modal current density source

II- Formulation and solution of boundary value problems with modal electromagnetic field sources

II-1- Equivalent circuit of RF devices excited by modal sources

II-2- Formulation of the boundary value problem based on Kirchhoff's and Ohm's laws

II-3- Numerical solution of the boundary value problem

II-4- Extraction of an equivalent electrical circuit from HF devices

III- Applications

III-1- Equivalent inductance of a metallized hole in a microstrip line

III-2- Input impedance of a rectangular metal and hollow waveguide cavity

III-3- Equivalent circuit of a width jump in a microstrip line

V- Prospects in the field of electromagnetic modeling of guiding structures using equivalent electrical circuits

Pre-requisites

The course "Physical Analysis of Guiding Structures" in 2A Semester 8

HIGH FREQUENCY EMBEDDED SYSTEMS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOS6G
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Microwave and Optical Sensors	Matière				
HF optoelectronic components and circuits	Matière				
Internet of Things	Matière				
Passive high frequency devices in waveguide technology	Matière				

Microwave and Optical Sensors



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE12A
- **Open to exchange students:** Yes

Presentation

Objectives

Raise students' awareness of the many possible applications and wide variety of industrial sectors.

Teach them, through analysis of the physical principle, to quickly identify the advantages/disadvantages of the device and make an informed choice based on specifications and customer needs.

Microwave sensors section

Become familiar with the measurement of electric and magnetic fields in radio frequency and microwave applications in telecommunications and other industries, through the modeling and characterization of the most commonly used electric and magnetic field probes, and also through the use of standard microwave measurement instruments.

Description

This is an introduction to industrial applications of laser systems.

The course is based on an introduction to physical principles (time of flight, interferometry, triangulation, etc.), their respective advantages/disadvantages, and therefore a critical and comparative analysis of their limitations.

Examples of commercially available devices are presented, as well as numerous applications in sectors as varied as aeronautics and space, the environment, biomedicine, metallurgy and mechanics, automotive, etc.

Microwave sensors section

Electromagnetic probes: electromagnetic analysis of probes – electrical diagram models – characteristics of E and H probes – analysis of reference probes – probe design

Standard RF and microwave measurement instruments: Theoretical review of spectral analysis and dipole and quadrupole analysis in terms of S parameters – Block diagram of standard instruments and networks – Main characteristics of spectrum analyzers and networks – Choice of instruments according to applications

Applications: characterization of RF and microwave sources, components, and devices using probes, spectrum analyzers, and networks (examples: CW mode RF generator/preamplifiers/magnetic probes/electrical probes/directional couplers (waveguide version/planar version)/inductive coupling system, etc.)

Pre-requisites

Optoelectronics (laser operating principles and main properties)

Microwave techniques (electromagnetic theory, transmission lines, electromagnetic waveguides, resonant cavities, microwave circuits, S-parameters)

HF optoelectronic components and circuits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE12B
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the drivers behind the technological choices that enable the creation of high-speed fiber optic communication systems.

Be able to design a high-frequency fiber optic communication system.

Analyze the performance limits of fiber optic communication systems and identify the limiting factors.

Description

This course presents the latest developments in optoelectronic systems in the high-frequency domain, with a focus on short-range telecommunications applications such as the 10Gb Ethernet standard. The modeling of components essential to these systems, such as laser diodes, photodiodes, and electro-optical modulators, is presented in detail. The design of circuits dedicated to high-frequency modulation of laser diodes and amplification of photodetected signals allows for a system-level approach to the design of communication systems in the GHz range.

Pre-requisites

Knowledge of semiconductor components for optics

Knowledge of fiber optic telecommunications (structure of an optical fiber, attenuation, and dispersion).

Basic knowledge of noise in electronics

Passive high frequency devices in waveguide technology



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE13A
- **Open to exchange students:** Yes

Presentation

Objectives

Discover the fields of application of metal waveguide structures, learn to differentiate between and choose between metal waveguide structures and transmission line structures, and distinguish the field of application of each; Learn to choose the metal waveguide(s) according to the intended industrial or scientific applications, and dimension the waveguides for specific cases

Know how to use the concepts of equivalent dipoles and equivalent quadripoles in the description of assemblies with resonant cavities, and deduce the characteristic parameters; know how to design resonant cavities and excitation circuits using formal calculations

Know how to use the concepts of impedance inverters in the design of half-wave microwave filters according to given specifications

Understand how waveguide transitions work and know how to implement an impedance transformer

Description

- Characteristics of metal waveguides
- Resonant cavities and electromagnetic resonators
- Microwave filters in metal waveguides

- Waveguide transition/impedance transformer

Pre-requisites

Basic elements of electromagnetism and wave propagation; basic concepts of linear electrical circuits in steady-state sinusoidal conditions; complex notation representation; vector analysis; matrix calculus

MICROWAVE CIRCUITS AND ELECTROMAGNETIC COMPATIBILITY



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOTKA
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Antenna networks	Matière				
Space antennas	Matière				
Aeronautical EMC 1	Matière				
Space Embedded Systems Conferences	Matière				
Microwave power amplifiers	Matière				
Aeronautical EMC 2	Matière				

Antenna networks



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE13B
- **Open to exchange students:** Yes

Presentation

Objectives

Know how to calculate the fundamental descriptors of phased arrays – Know how to physically interpret the radiation of phased arrays – Know the fundamental properties of phased arrays – Design a phased array based on specifications

Description

- I- Phased arrays: definition and objectives
- II- Array factor: assumptions and definition
- III- Antenna arrays with uniform amplitudes and progressive phase
 - III-1 Definition
 - III-2 Design and fundamental descriptors in the "large array" assumption
- IV- Antenna arrays with non-uniform amplitudes
 - IV-1 Definition
 - IV-2 Design and fundamental descriptors of a binomial array

IV-3 Design and fundamental descriptors of a Dolph-Tschebyscheff array

V- Prospects in the field of antenna arrays

Pre-requisites

The following subjects: Planar Antennas and Radiating Openings (code N8EE08B) – Electromagnetic Radiation and Antennas (code N8EE26A)

Space antennas



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE13C
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of this course, students will have:

- Knowledge of the principle of reflector antennas and reflector technology.
- Knowledge of a wide variety of horn antennas (ridged, multi-mode, corrugated, etc.).
- Knowledge of multi-beam coverage, its benefits, and how it works.
- Knowledge of active antennas.
- Knowledge of beamforming networks.

An overview of in-flight antenna solutions is presented for different types of applications (LEO, GEO, telemetry and remote control, GNSS, etc.).

The objective is to pre-dimension a reflector antenna for a telecommunications satellite, highlighting the key design parameters.

The goal is to create a directional antenna operating in circular single polarization with a small footprint in the horizontal plane. Axial radiation ("end-fire") helical antennas are excellent candidates for meeting this need. To design the helical antenna, we will rely on:

- A parametric model of a single-wire helix in HFSS (Monofilar_Helix_Antenna.aedt)

- A chart describing the radiation modes (radial, axial, conical, etc.) of the helix as a function of geometric characteristics (normalized to wavelength):

- o Circumference C

- o Pitch S

Description

This course presents different antennas used in the space sector.

Pre-requisites

Electromagnetic radiation

Antenna networking

Aeronautical EMC 1



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE13D
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of the course, students will be able to:

- identify the origins of coupling
- use the formalism of line theory on single- and multi-conductor cables
- compare different models to describe field-cable coupling
- explain the purpose and functioning of magnetic shielding and electrical shielding
- measure surface impedance and/or transfer impedance with vector network analyzers

Description

This course presents low- and high-frequency electromagnetic compatibility and methods for modeling coupling and shielding issues in electronic systems.

Pre-requisites

Electromagnetism

Line theory

Microwave power amplifiers



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE14A
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of this course, students will be able to:

- Describe the two possible technologies (solid-state power amplifiers and electronic tubes) and name the three main families of tube amplifiers
- List their advantages and disadvantages
- Choose the most suitable technology for a given frequency range and power range
- Identify the different physical phenomena present in a tube amplifier

Description

This course covers microwave amplifiers used in microwave chains (> 1 GHz) to generate high power (> 1 W). These circuits can be used in many applications, including defense, radar, telecommunications, science, medicine, ovens, and GPS.

Pre-requisites

Microwave waveguides

Microwave amplifiers (gain, IM3, efficiency, etc.)

Aeronautical EMC 2



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE13E
- **Open to exchange students:** Yes

Presentation

Objectives

Introduction of aircraft certification and qualification ratings in terms of electromagnetic compatibility (EMC), particularly in strong fields and lightning strikes.

Description

1. Aircraft qualification in strong fields.
 2. Aircraft qualification in lightning.
-

Pre-requisites

Electromagnetism – electromagnetic compatibility – microwave techniques – plasma physics – materials physics.

PROPAGATION PHENOMENA AND RADAR



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

- **Ametys Code:** N9EE15
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Actual propagation of electromagnetic waves	Matière				
Electromagnetic diffraction analysis / Radar equipment	Matière				
Radar project	Matière				

Actual propagation of electromagnetic waves



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE15B
- **Open to exchange students:** Yes

Presentation

Objectives

Discover the influence of real terrain on the propagation of electromagnetic waves in wireless transmission of radio frequency and microwave signals; learn how to use and interpret Friis equations; learn how to evaluate the range of a microwave link in free space; learn how to estimate electric and magnetic fields in free propagation for a given transmitter

Know how to calculate the link budget in free propagation, as well as in the presence of a passive reflector

Understand the Huygens-Fresnel-Kirchoff formulation on the phenomenon of diffraction; know how to calculate Fresnel zones based on terrain problems; Know how to evaluate additional attenuation (AA) using the thin screen model (knife edge effect); know how to use different calculation models for multiple obstacles modeled as screens

Understand the electrical characteristics of different types of terrain and their role in evaluating link performance in multipath propagation; know how to calculate space waves and surface waves; understand their role in the design of transmission systems; Know how to calculate reflection parameters on curved surfaces; know how to evaluate the influence of the Earth's curvature on link balances; know how to perform the "line of sight" calculation.

Know the characteristics of tropospheric propagation; understand standard and non-standard refractions; know tropospheric diffusion models; understand the effects of gases and particles in the air on tropospheric propagation.

Description

- Causes of electromagnetic wave attenuation
- Diffracting screen model.
- Multi-path propagation in the presence of flat/curved surfaces
- Tropospheric propagation

Pre-requisites

Maxwell's equations; plane electromagnetic wave; representation in complex notation

Electromagnetic diffraction analysis / Radar equipment



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOPD9
- **Open to exchange students:** Yes

Presentation

Objectives

Know how to calculate and physically interpret the electromagnetic field backscattered by an antenna – Understand the modes of electromagnetic propagation of antennas and structures – Understand the main techniques and technologies for electromagnetic stealth and deception

Know how to determine the electronic architecture of a radar to detect information about a radar target. Also know how to qualify the radar target. Know how to perform the necessary tests to qualify the radar or the target alone.

Description

The electromagnetic field backscattered by any antenna will be analyzed using the antenna radiation pattern, then the electromagnetic backscatter of an antenna loaded with any impedance to arrive at the concept of the radar cross section of any antenna. The electromagnetic radiation pattern of antennas and structures will also be presented.

Several applications will be discussed: stealth and electromagnetic masking; electromagnetic deception. RFID tags will be discussed, as well as passive and wireless sensors. Perspectives in the field of electromagnetic diffraction analysis will be presented.

Once the object has been characterized. The operating principle of a radar is presented, as well as the electronic architectures used to characterize parameters such as distance, speed, or the Radar Equivalent Surface Area of the object in question. The principle of a radar target emulator is also discussed.

Pre-requisites

The Electromagnetic Radiation and Antennas and Physical Analysis of Guiding Structures courses from Semester 8 of 2A.

Radar project



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE15D
- **Open to exchange students:** Yes

Presentation

Objectives

Implement and test (simulation and measurement) a radar for a specific detection purpose. These projects are carried out in groups. Students must organize their work time on the various points and also choose how to simulate/measure the available components.

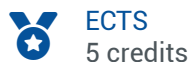
Description

In this project, students will be asked to design a radar with a specified detection objective using components available around Wi-Fi frequencies (2.45GHz). They will be asked to choose their electronic architecture, test it in simulation before implementing the radar and testing it in real conditions.

Pre-requisites

Courses from the same teaching unit: "Electromagnetic analysis of diffraction and radar architecture" and "Real propagation of electromagnetic waves."

ELECTIVE TEACHING UNIT



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **AmetyS Code:** M34HOM17
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
ADVANCED RADIOFREQUENCY ELECTRONICS	UE				5 credits
RF equipment	Matière				
MMIC	Matière				
MEMS	Matière				
MODELING	UE				5 credits
Variational methods for solving partial differential equations of physics	Matière				
Integral methods	Matière				
Plasma physics and applications	Matière				

MODELING



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HONLJ
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Variational methods for solving partial differential equations of physics	Matière				
Integral methods	Matière				
Plasma physics and applications	Matière				

Variational methods for solving partial differential equations of physics



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE11C
- **Open to exchange students:** Yes

Presentation

Objectives

To supplement the concepts covered in the study of partial differential equations with a more in-depth theoretical approach. To provide the theoretical foundations for tackling third-year courses in numerical methods.

Description

Variational approximation of boundary value problems.

Study of the existence and uniqueness of the solution.

Concepts in spectral theory of operators.

Pre-requisites

PDE and finite differences 1EEEE; Hilbert space 2EEEE-PN/SYSCOM

Integral methods



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HONTM
- **Open to exchange students:** Yes

Presentation

Objectives

To supplement knowledge for the numerical solution of Maxwell's equations and to deepen understanding of numerical programming methods

Description

Introduction to integral methods, in particular boundary integral methods, for solving Maxwell's equations:

- o Green's function and integral formulations
- o Boundary finite elements
- o Method of moments: Different formulations in free space EFIE, MFIE, CFIE
- o Other formulations

BE: Development in Fortran of the solution by boundary integral equations of the problem of diffraction by a metal obstacle

Pre-requisites

Numerical methods, Partial Differential Equations 1st year, Finite elements 2nd year

Plasma physics and applications



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE14E
- **Open to exchange students:** Yes

Presentation

Objectives

1. Basic concepts of plasmas and their applications
 - Debye length and plasma frequency
 - Concepts of collisions, cross section, distribution function
 - Calculation of the different moments of the Boltzmann equation
2. Magnetized plasmas
3. DC plasmas: ignition and breakdown of a continuous discharge
4. Generation of an RF plasma
5. High-pressure breakdowns: streamers, corona discharges, DBD
6. Main applications of non-equilibrium plasmas
 - Focus on plasma propulsion

Description

This course presents the different aspects of plasmas: their definition, properties, conditions of generation, and main applications.

Pre-requisites

Electromagnetism: knowledge of fields and associated forces.

Statistical thermodynamics: ideal gas law;

Fundamental principle of dynamics

Semestre 9 - Computational Physics (PN)



ECTS
30 credits



Component
École Nationale
Supérieure
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d'Informatique
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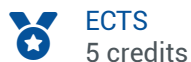
In brief

- **Ametys Code:** M8FQKNAV
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
ENVIRONMENT FOR INTENSIVE COMPUTING	UE				5 credits
BES langages avancés (C++, Python)	Matière				
Environnement Logiciel du Calcul Scientifique	Matière				
Techniques de génération maillage, pré/post processing	Matière				
NUMERICAL METHODS FOR DIFFRACTION PROBLEMS	UE				5 credits
Integral methods	Matière				
Electromagnetic diffraction analysis / Radar equipment	Matière				
PHYSICS FOR MECHATRONICS	UE				5 credits
Plasma physics and applications	Matière				
Advanced phenomena in electromechanical conversion	Matière				
Modeling of coupled phenomena	Matière				
Introduction to Magnetohydrodynamics	Matière				
EMC AND APPLIED MATHEMATICS	UE				5 credits
Aeronautic EMC 1	Matière				
Electromagnetic compatibility	Matière				
High Performance Computing	Matière				
Variational methods for solving partial differential equations of physics	Matière				
Multiphysics Models	Matière				
NUMERICAL METHODS AND OPTIMISATION	UE				5 credits
Topological Optimisation	Matière				
Finite element numerical modelling	Matière				
Optimal control	Matière				
Finished volumes	Matière				
SOFT AND HUMAN SKILLS 3EA S9	UE				5 credits
Professional Communication and English-Semestre 9	Bloc				
Scientific English	Matière				
Choix 2 Anglais Professionnel - 3A	Choix				
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				
CV Entretiens(3EA)	Matière				
Recherche doc.(3EA)	Matière				
CHOIX Careers and Management 3EA S9	Choix				
Entrepreneurship Project	Matière				
Corporate Project and Social Responsibility	Matière				

ENVIRONMENT FOR INTENSIVE COMPUTING



In brief

- **Ametys Code:** M8G8RA45
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
BES langages avancés (C++, Python)	Matière				
Environnement Logiciel du Calcul Scientifique	Matière				
Techniques de génération maillage, pré/post processing	Matière				

BES langages avancés (C++, Phyton)



Component

École Nationale
Supérieure
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M8G8RA63

Environnement Logiciel du Calcul Scientifique



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M8G8RA9A

Techniques de génération maillage, pré/post processing



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

> **Ametys Code:** M8G8RADD

Presentation

Objectives

L'objectif de ce cours sur le maillage est de rendre les étudiants autonomes pour la création d'une géométrie (CAO), et pour la création du maillage (structuré, non structuré, hexaédrique, tétraédrique, polyédrique, hybride, couche limite, maillage surfacique, ...) : notions de base, rôle et importance du maillage et de sa qualité dans la simulation numérique (y compris en HPC), présentation des différents algorithmes de maillage (avancée de front, sphère vide, ...). Le but est que les étudiants comprennent clairement ce qu'ils font en utilisant un mailleur et qu'ils aient une analyse critique de leur maillage en fonction du solveur qu'ils veulent utiliser et de la physique à résoudre.

Les principaux types de maillage (triangulaire et tétraédrique, quadrangulaire et hexaédrique, hybride, surfacique et volumique, polyédrique, ...) sont détaillés. Les algorithmes utilisés dans les mailleurs libres (Salome, Gmsh) ou commerciaux (Ansys tools, Simail) pour générer ces différents maillages sont présentés.

Un ensemble de règles et de bonnes pratiques concernant la génération des maillages est exposé ainsi que les critères de qualité associés aux différents types de maillage.

Un accent particulier est porté sur des conseils de mise en forme et de valorisation des résultats de simulation afin de mieux mettre en valeur les résultats obtenus dans ce cours comme en BEI ou plus tard dans leur carrière.

Description

- Cours MAILLAGE

Introduction / Exemples

Méthodes numériques et maillages

Algorithmes de maillage triangulaire et tétraédrique

Algorithmes de maillage quadrangulaire et hexaédrique

Méthodes hybrides

Maillages surfaciques

Maillages polyédriques

Bonnes pratiques de maillage / Critères de qualité

Conclusion générale sur les maillages

Maillages disponibles à l'ENSEEIH

Principes de construction des géométries

Cours VISU et POST-TRAITEMENT

Introduction

Contraintes techniques (images et vidéos)

Création d'une vidéo de qualité

Une visualisation de qualité : pièges à éviter, mise en forme à respecter, contenu, valorisation des résultats

- Logiciels de visualisation commerciaux / gratuits

Outils de visualisation et de post-traitement disponibles à l'ENSEEIH

- TRAVAUX DIRIGES

- 4h en commun sur un sujet avec le maître Salome pour valider les notions de base

- Mini-projets : En binôme les étudiants réalisent des mini-projets dans lesquels ils choisissent le sujet d'étude à mailler (statoréacteur, flèche, arc de triomphe, module de rentrée atmosphérique, sous-marin, dirigeable, coquillage, ornithorynque, ...), le maître (Salome, Gmsh, Ansys tools, StarCCM+, simail, comsol, ...) qu'ils veulent utiliser ainsi que le solveur (Code_Saturne, Ansys, StarCCM+, ...). L'évaluation est une soutenance orale qui porte sur ces mini-projets. Les maillages générés doivent avoir tourné sur le solveur de leur choix ...

NUMERICAL METHODS FOR DIFFRACTION PROBLEMS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

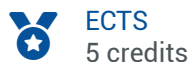
In brief

- > **Ametys Code:** M8G8R4L0
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Integral methods	Matière				
Electromagnetic diffraction analysis / Radar equipment	Matière				
	Nature	CM	TD	TP	Crédits

PHYSICS FOR MECHATRONICS



In brief

- **Ametys Code:** M8G8R6KD
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Plasma physics and applications	Matière				
Advanced phenomena in electromechanical conversion	Matière				
Modeling of coupled phenomena	Matière				
Introduction to Magnetohydrodynamics	Matière				

Advanced phenomena in electromechanical conversion



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE26B
- **Open to exchange students:** Yes

Presentation

Objectives

Familiarize students with the various secondary phenomena involved in the advanced design of electrical machines.

Description

The design of electric machines is primarily aimed at meeting torque, speed, or position specifications for a given application. However, there are many factors that can significantly impact the design. These include vibration, thermal, and electromagnetic phenomena. An advanced understanding of these phenomena allows them to be taken into account.

Pre-requisites

- magnetostatic
- modeling of electromagnetic systems by analytical calculation

Modeling of coupled phenomena



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE26C
- **Open to exchange students:** Yes

Presentation

Objectives

The course "Analytical Modeling of Coupled Phenomena" aims to familiarize students with the modeling of coupled electromagnetic and mechanical phenomena in asynchronous machines.

Description

Students will learn how to establish analytical models to describe the dynamic behavior of machines, taking into account the interactions between the magnetic field, rotor mechanics, and electric currents. Emphasis will be placed on studying the effects of asynchronism, slip, and losses on the overall performance of motors. Students will develop skills to solve these models using analytical methods and understand the impact of different configurations and operating conditions. Finally, case studies and practical simulations will enable students to validate theoretical models and apply this knowledge to the optimization of asynchronous machines in industrial applications.

Introduction to Magnetohydrodynamics



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N9EE26E
- **Open to exchange students:** Yes

Presentation

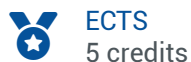
Objectives

The course "Analytical Modeling of Coupled Phenomena" aims to familiarize students with the modeling of coupled electromagnetic and mechanical phenomena in asynchronous machines.

Description

Students will learn how to establish analytical models to describe the dynamic behavior of machines, taking into account the interactions between the magnetic field, rotor mechanics, and electric currents. Emphasis will be placed on studying the effects of asynchronism, slip, and losses on the overall performance of motors. Students will develop skills to solve these models using analytical methods and understand the impact of different configurations and operating conditions. Finally, case studies and practical simulations will enable students to validate theoretical models and apply this knowledge to the optimization of asynchronous machines in industrial applications.

EMC AND APPLIED MATHEMATICS



In brief

- **Ametys Code:** M8G8R5CE
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Aeronautic EMC 1	Matière				
Electromagnetic compatibility	Matière				
High Performance Computing	Matière				
Variational methods for solving partial differential equations of physics	Matière				
Multiphysics Models	Matière				

Aeronautic EMC 1



Component

École Nationale
Supérieure
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M8G8R50N
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of the course, students will be able to

- identify the origins of coupling
- use the formalism of line theory on single- and multi-conductor cables
- compare different models to describe field-cable coupling
- explain the purpose and functioning of magnetic shielding and electrical shielding

Description

This course covers low- and high-frequency electromagnetic compatibility, methods for modelling coupling and shielding issues in electronic systems.

Pre-requisites

Electromagnetism

Line theory

Electromagnetic compatibility



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE29C
- **Open to exchange students:** Yes

Presentation

Objectives

Gain an understanding of the field of Electromagnetic Compatibility (EMC), its formalisms, methodologies, and analysis and measurement techniques.

Be able to analyze cases of conducted and radiated emissions.

Be able to analyze cases of susceptibility and immunity, both conducted and radiated.

Identify EMC coupling scenarios, differential and common modes, and the distinctions between near-field and far-field.

Be able to propose mitigating and/or preventive solutions: filtering, shielding, redesign

Description

Theoretical Section:

I - Overview of Electromagnetic Compatibility

II - Techniques and Tools for EMC Investigations

III - Methodologies and Techniques for Reducing EMC Risks

Applied Section/Practical Work:

-Summary/Applications: 7 EMC case studies on the architectures and electronic boards of an embedded mechatronic system.

-Comprehensive EMC analysis of an autonomous mobile system

-Emission spectra of power circuits

-Immunity cases for control circuits and sensors

Pre-requisites

Analog and Digital Electronics, RF and Microwave Electronics

Electromagnetism and Propagation Phenomena in Free Space and Guided Waves

Component Physics, Integrated Circuits, Packaging, Printed Circuit Boards (PCBs)

Power Electronics and Converters

High Performance Computing



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE33A
- **Open to exchange students:** Yes

Presentation

Objectives

To supplement the knowledge of linear algebra covered in S8 and introduce more recent numerical calculation methods for solving large-scale problems.

Description

- Iterative methods for solving linear systems:
 - o Richardson
 - o Krylov spaces: conjugate gradient, GMRES
- Low-rank methods for dense matrices
 - o Multipole methods, Adaptive Cross Approximation
 - o Hierarchical matrices
- Tensors
 - o Definitions and basic concepts

- o Storage format: CP, Tucker, Tensor-Train

Pre-requisites

Linear Algebra Course S8-EEEE

NUMERICAL METHODS AND OPTIMISATION



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M8G8R3G6
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Topological Optimisation	Matière				
Finite element numerical modelling	Matière				
Optimal control	Matière				
Finished volumes	Matière				

Topological Optimisation



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE33C
- **Open to exchange students:** Yes

Presentation

Objectives

The aim of the course is to present the fundamental principles of topological optimisation and the different ways of formulating an optimal design problem. It also aims to show the limitations of exhaustive or metaheuristic approaches and to explain the advantages of density methods associated with the adjoint for gradient calculation.

Description

This module introduces the topological optimisation approach and the motivations behind the optimal design of electromagnetic structures or devices. Students learn about the main formulations of the problem. The course highlights the difficulties associated with exhaustive methods or metaheuristics applied directly to solving topological optimisation problems, and explains why density-based approaches are a much more effective alternative. The use of the adjoint method to calculate the gradient is presented in detail using a comprehensive example applied to the design of a 2D magnetic circuit (magnetostatic equations). The practical work then allows us to implement a simple case of topological design, in particular the optimisation of pole pieces for a U-shaped 2D circuit, in order to link the theoretical aspects to an application inspired by a magnetic propulsion system.

Pre-requisites

The course requires a good understanding of partial differential equations and finite element methods. A basic knowledge of continuous optimisation (gradient, local optimum, simple constraints) and familiarity with a scientific language such as MATLAB or Python are recommended.

Finite element numerical modelling



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE27A
- **Open to exchange students:** Yes

Presentation

Objectives

Know how to model an electromagnetism/electrical engineering problem in order to perform a finite element calculation;
Understand how the finite element method works;
Apply the concepts learned in class using a free tool on simple electrical engineering examples.

Description

The course 'Numerical Modelling Using Finite Elements' will cover the following topics:

- modelling/formulating equations for the problem: choosing the right EDP, variable and boundary conditions for the device under study;
- using nodal finite elements for discretising scalar potentials in particular;
 - the use of vector finite elements for the discretisation of vector potentials or E, H, B, D fields, for example;
 - the use of formulations coupled with several fields (useful when dealing with different materials or when coupling physical phenomena);
 - additional complementary concepts concerning, in particular, the treatment of non-linear materials, the calculation of force-type quantities, and equivalent boundary conditions (to avoid meshing certain materials or large volumes of air).

Design office sessions will enable these concepts to be implemented using a 'free' finite element calculation tool.

Pre-requisites

Not essential, but it may be useful to have taken the second-year course on finite elements.

Optimal control



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Amety's Code:** N9EE27B
- **Open to exchange students:** Yes

Presentation

Objectives

The 'Optimal Control' course aims to provide students with an in-depth understanding of advanced control strategies applied to electrical machines. Students will learn how to design optimal control algorithms aimed at improving machine performance in terms of efficiency, accuracy and dynamics. Emphasis will be placed on robust control methods, as well as the use of techniques such as vector control, predictive control and model-based control. Students will also explore the challenges of integrating these techniques into complex industrial systems, while taking into account practical constraints such as power limitations and external disturbances. Finally, case studies and simulations will allow students to apply theoretical concepts to real-world projects, thereby consolidating their ability to design and optimise control systems for modern electrical machines.

Finished volumes



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE33D
- **Open to exchange students:** Yes

Presentation

Objectives

Construction of the Finite Volumes scheme for the numerical solution of unsteady Maxwell's equations and introduction to other specific schemes (Finite Differences in the time domain, discontinuous Galerkin method)

Description

In this course, we aim to study the Finite Volume method for the numerical solution of Maxwell's equations in the time domain. The advantage of this scheme lies in its great flexibility (use of meshes closely resembling geometries, with different types of meshes, consideration of discontinuous materials, thin sheets, etc.) while remaining extremely efficient. Starting from Maxwell's time-domain equations, we demonstrate how to construct the scheme, first by following the standard methodology, which bridges the gap with the extensive literature on schemes developed in CFD, and then by using a purely electromagnetic flux construction. We also study various evolutions through increasing order, time-domain schemes, boundary conditions, and so on. Finally, we present a set of applications and two other schemes: the discontinuous Galerkin method (viewed as an evolution of Finite Volumes) and the Finite Difference Scheme specific to electromagnetism (FDTD). The module is divided into a lecture part and a practical part which will allow you to see how to program the scheme and test its properties.

SOFT AND HUMAN SKILLS 3EA S9



ECTS

 5 credits



Component

 École Nationale

 Supérieure

 d'Électrotechnique

 d'Électronique

 d'Informatique

 d'Hydraulique

 et des

 Télécommunications

In brief

- **Ametys Code:** M8G8R706
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Professional Communication and English-Semestre 9	Bloc				
Scientific English	Matière				
Choix 2 Anglais Professionnel - 3A	Choix				
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				
CV Entretiens(3EA)	Matière				
Recherche doc.(3EA)	Matière				
CHOIX Careers and Management 3EA S9	Choix				
Entrepreneurship Project	Matière				
Corporate Project and Social Responsibility	Matière				

Professional Communication and English-Semestre 9



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

> **Ametys Code:** M8G8R7Q7

List of courses

	Nature	CM	TD	TP	Crédits
Scientific English	Matière				
Choix 2 Anglais Professionnel - 3A	Choix				
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				

Scientific English



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M8G8R7SR

Choix 2 Anglais Professionnel - 3A



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

> **Ametys Code:** M8G8R7W4

List of courses

	Nature	CM	TD	TP	Crédits
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				

Anglais Clinique



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M8G8R7YA

Anglais de Cambridge ou Projet



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M8G8R81Q

CV Entretiens(3EA)



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

> **Ametys Code:** M8G8R8UU

Presentation

Objectives

Ils consistent à accompagner les étudiants pour les aider à :

- rédiger des écrits professionnels, CV et lettre de motivation, en utilisant les particularités des formats papier ou électronique, et de la communication synchrone et asynchrone et en répondant aux demandes des entreprises.
- développer les qualités en communication écrite et orale : réussir les entretiens de recrutement, maîtriser d'une façon harmonieuse les relations professionnelles (interculturalité, relations hiérarchiques, team building),
- convaincre et persuader lors d'entretiens de recrutement et jusqu'à la signature du contrat de travail,
- finaliser et optimiser le P.P.P (Projet Professionnel Personnel).

Description

- analyser et synthétiser efficacement de façon à mieux communiquer oralement et à l'écrit, à propos de thèmes suivants : réussir son entretien de recrutement en présentiel en distanciel, les speed net working, le marché de l'emploi, le développement des starts up les codes du recrutement, point sur les outils du recrutement, utilisation de LINKEDIN, négocier son contrat de travail, son salaire, l'intérêt de l'expatriation...

- apprendre à mieux se connaître (ses points faibles et ses points forts) afin de mieux communiquer.

METHODE

- apports théoriques, «Communication écrite, orale», et «Bien démarrer sa vie professionnelle»
- mise en situation, avec la présentation orale (diaporama) et écrite d'un sujet en lien avec le recrutement,
- connaissance de soi, pédagogie inversée, développement du leadership, accompagnement adapté.

EVALUATION DES ETUDIANTS

Elle portera sur la réalisation d'exercices concernant : la rédaction d'un CV et d'une lettre de motivation efficaces, des simulations d'entretiens de recrutement, des présentations écrites et orales à propos des thèmes précisés ci-dessus.

ORGANISATION DES COURS

Les cours « Insertion professionnelle » s'organisent ainsi, il y a un décloisonnement des enseignements, ils sont orientés vers la recherche de stage/emploi et la communication :

- des forums du recrutement et des carrières sont proposés,
- les cours et TD sont donnés durant le semestre 1 de l'année universitaire (bac +5), soit 8 heures.

Ce calendrier est ponctué d'échanges par e-mail et en face à face avec l'enseignante, en fonction des besoins de l'étudiants.

Recherche doc.(3EA)



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M8G8R8Z0

CHOIX Careers and Management 3EA S9



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M8G8R92D

List of courses

	Nature	CM	TD	TP	Crédits
Entrepreneurship Project	Matière				
Corporate Project and Social Responsibility	Matière				

Entrepreneurship Project



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M8G8R94B

Corporate Project and Social Responsibility



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M8G8R988

Semestre 9 - Control Architecture Computer Science and Embedded Systems (ACISE)



ECTS
30 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M8FQM46A
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
SYSTEMS CONTROL, FILTERING AND DIAGNOSTIC	UE				5 credits
Filtering estimation	Matière				
System Monitoring and Diagnostics	Matière				
Multidimensional Systems	Matière				
SYSTEMS OPTIMISATION AND THEIR CONTROL	UE				5 credits
Robust control	Matière				
Optimal Control	Matière				
Combinatorial optimization	Matière				
Opti TER	Matière				
Linear programming and unimodularity	Matière				
Continuous optimization	Matière				
MODELING, ANALYSIS, SIMULATION OF DISCRETE SYSTEMS	UE				5 credits
Modeling and analysis of discrete systems	Matière				
Simulation of discrete event systems	Matière				
Planning and Scheduling	Matière				
Hybrid Dynamic Systems	Matière				
Flexible Workshop TER	Matière				
ADVANCED CONTROLLED SYSTEMS	UE				5 credits
Adaptive and predictive controls	Matière				
Aeronautical systems	Matière				
Robotics: Modeling and Control	Matière				
Advanced Control TER	Matière				
Electrical Systems Control	Matière				
ADVANCED CRITICAL COMPUTING SYSTEMS	UE				5 credits
IT Security	Matière				
IT operational security	Matière				
Safety Testing and Evaluation	Matière				
Development of critical computer systems	Module				
SOFT AND HUMAN SKILLS 3EA S9	UE				5 credits
Professional English-LV1-Semestre 9	Bloc				
Anglais Scientifique	Matière				
Choix 2 Anglais Professionnel - 3A	Choix				
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				
CV Entretiens(3EA)	Matière				
Recherche doc.(3EA)	Matière				
CHOIX SHS 3EA S9	Choix				
Entrepreneurship Project	Matière				
Corporate Project and social responsibility	Matière				

SYSTEMS CONTROL, FILTERING AND DIAGNOSTIC



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

- > **Ametys Code:** N9EE16
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Filtering estimation	Matière				
System Monitoring and Diagnostics	Matière				
Multidimensional Systems	Matière				

Filtering estimation



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE16A
- **Open to exchange students:** Yes

Presentation

Objectives

To understand the value of a system's internal variables using various estimation techniques based on measuring the system's outputs

Description

To control or optimize a system, it is often necessary to know the value of that system's internal variables. Since these are not directly accessible through measurement, they must be estimated. Estimation then consists of modifying the knowledge of the value of the internal variables based on values measured at the system outputs.

The course outline is as follows:

- 1- Static estimation
- 2- Discrete-time processes
- 3- Continuous-time processes

A BE is also offered on absolute, visual, and inertial navigation.

System Monitoring and Diagnostics



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE16B
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the overall situation in the field of electromechanical system diagnostics.

Identify the different functions involved in a diagnostic system.

Perform FFT analyses on real signals to create fault indicators.

Use the design of experiments method for lifetime modeling.

Description

Monitoring and fault diagnosis of electromechanical systems

1. The growing role of monitoring and fault diagnosis
2. Failures in electromechanical systems
3. Existing solutions for monitoring and fault diagnosis
4. Introduction to reliability
5. Diagnostic methods: classification and examples (BE)

6. Designing experiments for a reliability study (BE)

Lectures and computer-based assignments, based on problem-based learning

Pre-requisites

Basic mathematical functions

Basic electronic functions

Multidimensional Systems



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE16C
- **Open to exchange students:** Yes

Presentation

Objectives

Know how to analyze problems specific to multi-input and multi-output systems in terms of their representation and control. Know how to formulate the state representation and analyze the observability and controllability of the system.

Description

Representations of multidimensional systems: coupled differential equations, transfer matrix.

- Controllability and observability of multidimensional systems.
- Searching for a state representation of a multidimensional system from a transfer matrix: Gilbert's method, invariant method, rank 1 matrix decomposition.
- Control design: pole placement, canonical decomposition, eigenvector placement, state feedback, output feedback.

SYSTEMS OPTIMISATION AND THEIR CONTROL



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

- **Ametys Code:** N9EE17
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Robust control	Matière				
Optimal Control	Matière				
Combinatorial optimization	Matière				
Opti TER	Matière				
Linear programming and unimodularity	Matière				
Continuous optimization	Matière				

Robust control



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Amety's Code:** N9EE17A
- **Open to exchange students:** Yes

Presentation

Objectives

Present the methods allowing to take into account model uncertainties in the context of state-space models for linear time-invariant systems. Describe the numerical and mathematical tools based on convex optimisation and Lyapunov stability theory leading to Linear Matrix Inequalities (LMI) whose feasibility can be checked using very efficient numerical tools.

Description

Chapter 1 - Introduction

Discuss historical issues and the limitations of classical control design methods when significative model uncertainties are present.

Chapter 2 - Complements about linear-time-invariant systems

Summarize the main concepts used in robust control to formulate the control design problem through an optimization problem, if possible, convex. In particular, signal and system norms (H_2 and H_∞ norms), controllability and observability gramian, and associated computation methods, are presented.

Chapter 3 – Linear Matrix Inequalities

Introduce the concept of linear matrix inequality, give the first examples in the context of Lyapunov theory for linear-time-invariant systems (Lyapunov equation). Present and use some mathematical tools like Schur-complement or S-procedure to transform a control design problem in a way leading to LMI optimization problem.

Chapter 4 – Some control design techniques using LMIs

Using the results developed in the previous chapters, present the robust control designs techniques for uncertain linear time invariant systems described by state-space models. In particular, perturbation rejection and pole placement problems are detailed. The chapter focuses essentially on state-feedback but the case of output feedback is evoked.

Pre-requisites

Course on Modelling, analysis and control of linear systems : input-output model, state-space model

Course on Control of single input - single output systems

Course on Control of multi inputs – multi outputs systems

Basic course in mathematics

Optimal Control



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE17B
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the fundamental principles of optimal control for continuous or discrete dynamic systems. Know how to formulate, analyse and solve an optimal control problem using modern analytical and numerical tools

Description

This course presents the theoretical and practical foundations of optimal control applied to dynamic systems. It introduces the general formulation of a control problem: system dynamics, constraints on states and controls, and definition of a performance criterion. Classical methods are studied in detail, in particular Pontryagin's maximum principle. The course also covers numerical approaches such as shooting schemes and direct or indirect methods. Emphasis is placed on the interaction between theory, modelling and numerical computation, with examples from electromechanical control. The ultimate goal is to equip students with the skills to develop simple numerical methods for solving optimal control problems.

Pre-requisites

- *Basic knowledge of dynamic systems (differential equations, stability).
- *Continuous optimisation with constraints.

Combinatorial optimization



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE17C
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand the fundamental concepts and specificities of combinatorial optimization (notions of complexity, combinatorial explosion, etc.)
- Identify and model issues from different fields or specifications in the form of combinatorial optimization problems
- Solve combinatorial problems using exact tree methods (branch-and-bound) to guarantee the optimality of the solutions obtained
- Design metaheuristic approximation methods (genetic algorithms, tabu search, etc.) to generate solutions adapted to the context, without guaranteeing optimality but with limited execution time
- Implement the proposed algorithms and evaluate their performance on case studies from different fields: computer science, logistics, industrial engineering, etc.

Description

This course focuses on modeling and approximate or exact solving of NP-hard combinatorial optimization and decision problems encountered in various fields.

Pre-requisites

linear programming

Opti TER



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE17D
- **Open to exchange students:** Yes

Presentation

Objectives

Implement methods for optimizing energy flows in an electrical microgrid.

Description

This TER illustrates optimization techniques (covered in the continuous optimization course N9EE17F and the linear programming course N9EE17E) using a concrete example. The proposed case study concerns a microgrid comprising photovoltaic energy production combined with a storage battery to supply a residential load (family home). The objective is to reduce the household's electricity costs by taking advantage of off-peak/peak pricing and exploiting the degree of freedom offered by storage. The proposed benchmark allows us to test different strategies for planning energy flows over 24 hours, based on expertise (heuristics, rule-based controls) or optimization techniques: gradient methods, geometric methods, stochastic metaheuristics (genetic algorithms, particle swarm optimization, simulated annealing) or mixed-variable linear programming (after linearization of the problem).

Pre-requisites

courses N9EE17F and N9EE17E

Linear programming and unimodularity



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE17E
- **Open to exchange students:** Yes

Presentation

Objectives

- Model simple problems using linear programs, translating the constraints of the problem into systems of linear equations or linear inequalities
- Solve these programs using the graphical method for the special case with two variables and using the simplex algorithm for the general case
- Provide geometric and economic interpretations of the different outputs of this algorithm, based in particular on duality.
- Understand the property of unimodularity and know how to solve classic maximum flow and minimum cost flow problems

Description

Linear programming is the fundamental tool for modeling and solving optimization problems in operations research, which are of great practical importance: assignment problems, transportation, networks, production, etc. This course is limited to problems with continuous variables. The case of binary or integer variables, which is very common in practice, is covered in the course "Combinatorial Optimization," for which this course is a prerequisite.

Pre-requisites

Linear algebra

Continuous optimization



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE17F
- **Open to exchange students:** Yes

Presentation

Objectives

Understand and master optimization methods dedicated to solving continuous nonlinear problems.

Description

This course provides a brief overview of the state of the art in optimization methods for solving nonlinear and continuous problems. The various topics covered in the different chapters include:

- Formulating a single-objective optimization problem (without constraints), optimality conditions, and classification of the different methods used to solve a problem;
- One-dimensional optimization methods: interval subdivisions, quadratic interpolation, zero crossing of the objective function derivative;
- Gradient-based optimization methods: steepest descent, accelerated or conjugate gradient, Gauss-Newton or Quasi-Newton techniques;
- Geometric optimization methods: fixed or adapted directions during the search (Gauss-Seidel, Powell, Hooke & Jeeves), Nelder & Mead Simplex;
- Stochastic optimization methods: simulated annealing, evolutionary algorithms and nesting methods, particle swarms;

- Formulation of an optimization problem under inequality constraints: Lagrangian concept, KKT optimality conditions, penalization methods;
- Formulating a multi-objective problem: Pareto optimality, a priori decision on objectives (weighted objectives, epsilon constraint methods, global criterion method), a posteriori decision on objectives (using population-based algorithms), progressive or sequential techniques (lexicographic method).

Pre-requisites

Basic mathematical concepts related to functions with multiple variables, vector and matrix operators, and geometry.

MODELING, ANALYSIS, SIMULATION OF DISCRETE SYSTEMS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

- > **Ametys Code:** N9EE18
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Modeling and analysis of discrete systems	Matière				
Simulation of discrete event systems	Matière				
Planning and Scheduling	Matière				
Hybrid Dynamic Systems	Matière				
Flexible Workshop TER	Matière				

Modeling and analysis of discrete systems



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE18A
- **Open to exchange students:** Yes

Presentation

Objectives

Understanding and mastering formal tools for modelling and analysing concurrent systems, in particular coloured Petri nets, integrating time management (temporal, T-timed, P-timed), stochastic, possibilistic, hybrid, nested, etc.

Description

This course focuses on concurrent systems where concurrent and sometimes non-deterministic processes must be carried out with various constraints: order of event execution, interactions between subsystems, time. It aims to establish a formal and graphical modelling and analysis framework, with simulation and analysis tools using ordinary Petri nets (low-level PN) and high-level Petri nets (high-level PN).

Pre-requisites

N8EE16E: Petri network

Simulation of discrete event systems



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE18B
- **Open to exchange students:** Yes

Presentation

Objectives

- Master discrete event simulation software (Arena)
- Build simulations of industrial, logistics, or service systems using this software
- Analyze system performance (throughput, wait times, resource utilization, etc.) and propose improvements.
- Validate the simulation model against the actual specifications.
- Write a technical report presenting the results and recommendations.

Description

The increasing complexity of systems sometimes requires the use of simulation as a means of study during the design phase or to evaluate the performance of strategic choices before acting on the actual system. This BE allows students to build a simulation of a system and analyze it to draw reliable and preferably general conclusions. This practical project aims to apply the theoretical concepts covered in the Petri nets and scheduling courses to optimize performance and flow management in an industrial, logistics, or service system.

Pre-requisites

Petri net, discrete event simulation, scheduling

Planning and Scheduling



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE18C
- **Open to exchange students:** Yes

Presentation

Objectives

- Know the tools and methods for solving the main types of scheduling problems
- Know when and how to apply them

Description

Scheduling involves assigning tasks to resources and over time in order to optimize a given criterion, while respecting constraints. This course covers the challenges and methods of planning and scheduling in systems (production, logistics, IT, etc.).

Pre-requisites

combinatorial optimization

Hybrid Dynamic Systems



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE18D
- **Open to exchange students:** Yes

Presentation

Objectives

Analysis and control of hybrid dynamic systems

Description

The course begins by explaining the reasons for studying hybrid dynamic systems. These include the existence of physical systems combining continuous dynamics, switching and/or pulses, such as power converters or network-controlled systems. Furthermore, certain physical system control objectives cannot be achieved using conventional continuous controls.

Subsequently, methods for modelling and analysing the stability (in the Lyapunov sense) of hybrid dynamic systems are presented. Finally, several methods for synthesising hybrid controls are detailed.

Students apply hybrid control laws to a power converter as part of a design office project. The closed-loop performance is compared to that of a conventional direct control system.

Pre-requisites

N8EE13C - Non-linear control

N8EE13A - State space

Flexible Workshop TER



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE18E
- **Open to exchange students:** Yes

Presentation

Objectives

Implement an optimized decision-making system based on Petri nets for a flexible workshop.

Description

Ensure compliance with a production sequence for different objects that must pass through stations dedicated to different operations, using a circuit and a shuttle for transportation.

Ensure that several objects are produced at the same time (Work In Progress >1).

Using a Petri net, propose a solution for managing several shuttles to optimize the production cycle.

Pre-requisites

Petri net, Discrete Event Systems

ADVANCED CONTROLLED SYSTEMS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

- > **Ametys Code:** N9EE19
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Adaptive and predictive controls	Matière				
Aeronautical systems	Matière				
Robotics: Modeling and Control	Matière				
Advanced Control TER	Matière				
Electrical Systems Control	Matière				

Adaptive and predictive controls



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE19A
- **Open to exchange students:** Yes

Presentation

Objectives

Master the basic concepts of adaptive and predictive control and carry out an initial implementation on Matlab

Description

The course details the motivations, showing the limitations of LTI modeling for representing real systems. The major levers of adaptive and predictive control design are discussed and illustrated using gain sequencing methods, MRAC, and classic predictive control (quadratic cost and linear constraints). The course includes exercises to prepare for the final exam, which focuses on the control of a nonlinear MIMO system (this year, a set of interconnected tanks).

Pre-requisites

Linear control (1A), state space (2A)

Aeronautical systems



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE19B
- **Open to exchange students:** Yes

Presentation

Objectives

- Build the model, i.e. the set of differential equations governing the movement (attitude and position) of an aircraft in 3D space, taking into account the environment (gravity, aerology).
- Implement state space modelling and state feedback control for single-input and multi-input cases.
- Perform linear quadratic (LQ) state feedback synthesis and LQG control
- Understand standards for linear systems, H_∞ requirements for closed-loop systems, H_∞ control and H₂ control for aeronautical vehicles

Description

This course examines the design of control laws for aeronautical vehicles.

Pre-requisites

- State space
- Non-linear control

Robotics: Modeling and Control



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE19C
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the different modeling elements for controlling robotic structures

Description

Homogeneous 3D coordinate transformation matrices for mobile robots or manipulators

Kinematic and dynamic models for control

Conventional, dynamic, and hybrid position-force control structures

BE: implementation of modeling and control blocks in Matlab-Simulink

Pre-requisites

Point mechanics. Linear algebra (vector and matrix). Control architecture.

Advanced Control TER



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE19D
- **Open to exchange students:** Yes

Presentation

Objectives

- 1) Develop a holistic methodology for designing control architectures: from theoretical system modeling to the implementation of controllers on real-time computers.
- 2) Acquire the ability to independently develop an engineering-type approach to address a control issue while meeting the requirements of a specification.
- 3) Independently acquire knowledge and expertise from technical documentation and scientific literature, then apply it to solve the problem at hand.

Description

Format: The study and research topic (TER) "Advanced Control" is primarily a TER. In this context, an open-ended problem is posed, for which there is no single answer. In order to develop students' ability to methodically design an approach to solve this problem, teaching is conducted in a semi-supervised manner. This gives students the opportunity to explore different avenues independently.

Theme: The problem to be solved involves designing a control law to achieve positional control of a translator-type electromechanical system (a system designed to move loads, as found in various industrial sectors). This design implements a comprehensive approach which, based on a given set of specifications, begins with modeling the system to be controlled. Based on this model, initial conventional controllers are developed in simulation, then their ability to meet the specifications is quantified and analyzed. More advanced controllers are then designed and studied to assess whether they provide a better response to the specifications. Among the various controllers analyzed, a choice must be made as to which one will then be discretized for real-

time implementation on the actual device. Experimental validation on the translator is the final step, allowing for final adjustments to the controllers in relation to the required performance to be achieved.

Pre-requisites

- Methodologies for modeling dynamic systems for control purposes (multiple courses within the Energy program),
- Synthesis of P, PI, PID, and other types of controllers, and selection of the synthesis method based on the characteristics of the system to be controlled (in conjunction with the course "N7EE05C: Synthesis of Controllers and Control Architectures"),
- Modeling of systems in state space (Course "N8EE13A: Analysis and synthesis of systems in state space"),
- Synthesis of discrete controllers (in conjunction with the Course "N7EE05B: Sampled systems"),

Electrical Systems Control



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE19E
- **Open to exchange students:** Yes

Presentation

Objectives

The main objective is to illustrate and implement, via numerical simulation, general automation principles for electrical energy conversion and processing systems. The aim is therefore to develop expertise in electrical system control by combining knowledge from electrical engineering and system control techniques in the broadest sense.

Description

The first part of the course is devoted to presenting general control concepts from linear, nonlinear, and sampled-data control, as well as some key principles for energy conversion (vector control of electric machines and vector PWM for three-phase inverters). Students then divide into groups (pairs or trios) and choose a topic from a list, which they then simulate using MATLAB-SIMULINK. The process involves modeling and simulating the object to be controlled, followed by designing a control law that meets the specifications. Students must then test and evaluate the performance obtained. At the end of the sessions, each group writes a report detailing the steps taken and the results obtained.

List of topics offered:

- Three-phase PWM rectifier, control on the abc axes + voltage regulator and PLL
- Single-phase active filter with PWM loop, RST regulator for currents, and global approach for harmonic references.
- Three-phase active filter with PWM loop, RST regulator for currents, and global approach for harmonic references

- Single-phase rectifier with PWM loop, RST regulator for currents and voltage + PLL
- Smooth-pole synchronous machine, vector control and cascade control for speed and position.
Smooth-pole synchronous machine, scalar control and state feedback for speed and position.
- Three-phase asynchronous machine, direct vector control and speed control and flux observer.
- Three-phase asynchronous machine, indirect vector control and cascade speed and position control.

Pre-requisites

Linear Systems Automation N7EE05B, N7EE05C, N7EE05D

Electrical Networks N7EE04D

Electrical Machines N7EE03B

Automatic and Nonlinear Systems N8EE13A, N8EE13B, N8EE13C, N8EE13D

ADVANCED CRITICAL COMPUTING SYSTEMS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

- **Ametys Code:** N9EE20
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
IT Security	Matière				
IT operational security	Matière				
Safety Testing and Evaluation	Matière				
Development of critical computer systems	Module				

IT Security



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE20A
- **Open to exchange students:** Yes

Presentation

Description

Introduction to the basic concepts of information system security (classification of attacks, cryptography, evaluation)

Illustration with examples (DES/AES, RSA, Diffie-Hellmann, electronic signatures)

Authentication and authentication protocols without knowledge sharing (Needham-Schroeder, Fiat-Shamir). Examples: Kerberos, smart cards.

Protection in computer systems (discretionary and mandatory security policies) and examples.

Concepts of intrusion tolerance (Shamir threshold schemes, etc.).

Pre-requisites

Basic knowledge of computer science (hardware, operating systems, languages).

IT operational security



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE20B
- **Open to exchange students:** Yes

Presentation

Description

General information, definitions, and basic concepts (attributes, constraints), means of operational safety (prevention, tolerance, elimination, prediction), and measures

Fault tolerance techniques (fault assumptions, basic techniques, replication strategies) and architectural solutions

Validation techniques, in particular through fault injection (principles, robustness analysis, examples of tools and experimental results)

Examples of industrial systems (e.g. Airbus A320, Boeing B777), summary and conclusion

TER "Critical System" associated with this course

Pre-requisites

Basic knowledge of computer science (hardware, operating system, language)

Concept of behavioral modeling of computer systems

Safety Testing and Evaluation



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE20C
- **Open to exchange students:** Yes

Presentation

Description

Introductory concepts: purpose of testing, other verification approaches (reviews and inspections, abstract interpretation, theorem proving, model checking, symbolic execution), cost of fault elimination, oracle problem, test selection problem.

Structural testing methods: control graph, coverage criteria (instructions, branches, paths, loops, MCDC).

Functional testing methods: equivalence classes and boundary values, decision table coverage, testing using a finite state machine.

Non-deterministic generation: fuzzing, operational testing, testing based on metaheuristic search.

Illustration with examples.

Evaluation:

Failure prediction.

Ordinal (or qualitative) and stochastic (or quantitative) evaluations.

Stable vs. evolving (increasing, decreasing) reliability.

Reliability measurements (or metrics).

Evaluation approaches: modeling (FMEA, reliability diagrams, fault trees), measurements.

Critical systems

Pre-requisites

Basic knowledge of computer science (hardware, operating systems, languages)

Concept of behavioral modeling of computer systems

Development of critical computer systems



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** ELP9
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand the constraints (or non-functional specifications) as well as the hardware and software design elements of embedded systems.
 - Know and apply UML modeling and the principles of object-oriented development.
-

Description

This course is dedicated to the design and development process for embedded systems.

Pre-requisites

- N7EE01A Object-Oriented Design and Programming
- N7EE01B Principles of Operating Systems

- N7EE01C Computer Architecture

Semestre 9 - Advanced Electromechanics (EMA)



ECTS
30 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M8FRAQ2Y
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
PHYSICS FOR MECHATRONICS	UE				5 credits
Advanced phenomena in electromechanical conversion	Matière				
Introduction to Magnetohydrodynamics	Matière				
Modeling of coupled phenomena	Matière				
NUMERICAL METHODS AND OPTIMISATION	UE				5 credits
Finite element numerical modelling	Matière				
Optimal control	Matière				
Optimised sizing of electrical machines	Matière				
Numerical modelling of machines	Matière				
DESIGN OF ELECTROMECHANICAL SYSTEMS	UE				5 credits
Design elements of static converters	Matière				
Mechanical design of actuators and generators	Matière				
Introduction to CAD	Matière				
Electric Generators	Matière				
ARCHITECTURES OF MECHATRONIC SYSTEMS	UE				5 credits
Multidimensional Systems	Matière				
Electric actuator control strategy	Matière				
TER Electric Actuator Control	Matière				
Electromagnetic compatibility	Matière				
Filtering estimation	Matière				
APPLIED MECHATRONICS	UE				5 credits
TER Advanced Control (EMA)	Matière				
Elastic metamaterials and actuators for space (Universeh)	Matière				
Winding techniques for electrical machines	Matière				
System Monitoring and Diagnostics	Matière				
SOFT AND HUMAN SKILLS 3EA S9	UE				5 credits
Professional English-LV1-Semestre 9	Bloc				
Anglais Scientifique	Matière				
Choix 2 Anglais Professionnel - 3A	Choix				
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				
CV Entretiens(3EA)	Matière				
Recherche doc.(3EA)	Matière				
CHOIX SHS 3EA S9	Choix				
Entrepreneurship Project	Matière				
Corporate Project and social responsibility	Matière				

PHYSICS FOR MECHATRONICS



ECTS
5 credits



Component
École Nationale
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d'Électronique
d'Informatique
d'Hydraulique
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Télécommunications



Semester
Automne

In brief

- > **Ametys Code:** N9EE26
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Advanced phenomena in electromechanical conversion	Matière				
Introduction to Magnetohydrodynamics	Matière				
Modeling of coupled phenomena	Matière				

NUMERICAL METHODS AND OPTIMISATION



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

- > **Ametys Code:** N9EE27
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Finite element numerical modelling	Matière				
Optimal control	Matière				
Optimised sizing of electrical machines	Matière				
Numerical modelling of machines	Matière				

Optimised sizing of electrical machines



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE27C
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the principles, advantages and limitations of metaheuristics for the global optimisation of complex problems. Know how to apply and configure modern stochastic methods for the optimised dimensioning of electrical machines.

Description

This course introduces global optimisation techniques based on stochastic and metaheuristic approaches, which are now widely used in the advanced design of electrical machines and actuators. After presenting design issues (electromagnetic models, geometric and thermal constraints, multi-criteria objective functions), the course details the main families of metaheuristics: simulated annealing, tabu search, VNS, genetic algorithms and multistart strategies. The principles, parameter settings, exploration/exploitation mechanisms and stopping criteria are explained through numerous examples. A significant part of the course is devoted to the integration of these methods with physical or numerical models (FEM, analytical models, surrogate modelling, multi-fidelity approaches), as well as strategies for reducing computational costs in industrial design problems. Comprehensive case studies on synchronous motors with magnets allow the theoretical aspects to be linked to concrete applications. The ultimate goal is to give students operational mastery of metaheuristics for solving realistic design problems that are highly non-convex and may be noisy or multimodal.

Pre-requisites

- Fundamentals of numerical optimisation (gradients, descent methods, concepts of convexity).
- Basic knowledge of electromagnetism applied to electrical machines (field models, losses, torques).
- Concepts in numerical simulation (FEM or parametric modelling).
- A plus: having taken a course in unconstrained optimisation or classical continuous optimisation.

Numerical modelling of machines



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE27D
- **Open to exchange students:** Yes

Presentation

Objectives

The course 'Numerical Modelling of Machines' aims to introduce students to the use of ANSYS Maxwell software for modelling and analysing electrical machines.

Description

Students will learn how to create detailed digital models of machines such as motors, generators and transformers using the software's electromagnetic simulation tools. The focus will be on analysing magnetic fields, eddy current losses and the interaction between mechanical and electrical components within the machine. Students will also acquire skills to optimise machine design based on simulation results, improving efficiency, performance and reliability. Finally, practical work and case studies will enable them to apply these techniques to real industrial projects, thereby strengthening their mastery of digital simulation tools in the field of electrical machines.

Pre-requisites

Modelling of machines seen from terminals

DESIGN OF ELECTROMECHANICAL SYSTEMS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
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Télécommunications



Semester
Automne

In brief

- **Ametys Code:** N9EE28
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Design elements of static converters	Matière				
Mechanical design of actuators and generators	Matière				
Introduction to CAD	Matière				
Electric Generators	Matière				

Design elements of static converters



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE28B
- **Open to exchange students:** Yes

Presentation

Objectives

To acquire the knowledge necessary to contribute to the design of the inverter powering an AC machine, integrating aspects such as architecture, control, and semiconductor selection.

- + To be able to justify the power structure of the power converter (three-phase inverter) and identify the main sizing parameters.
- + To identify the degrees of freedom provided by the three-phase inverter structure and understand their variation at different time scales (instantaneous, in the low-frequency range relative to the switching frequency).
- + To know how to use the degrees of freedom to control the currents injected into the machine windings.
- + To understand power reversibilities (at the time scales of the switching period, the machine current period, and steady state).
- + To understand the operating constraints of the inverter's power supply stage, related to the inverter's power reversibilities.
- + To understand the inverter's filtering principle (DC stage) and size the filter components.
- + To understand the instability phenomenon resulting from the "constant power load" behavior of the inverter with its associated regulation
- + Understand the stabilization principle and design a dedicated circuit

- + Identify the losses generated in the semiconductor components of the inverter's switching cell, their nature (conduction or switching), and their location (transistor or diode)
- + Understand the datasheet content of a power transistor and a heat sink
- + Know how to size the number of power modules to use for a given current range
- + Know how to use a transistor and diode loss model in PLECS and analyze the simulation results
- + Understand the sizing of a heat sink and know how to simulate the dynamic thermal behavior of the circuit for several operating points

Description

2 lecture volumes: Architecture and Control (3 x 1.75 hours)

- HP Semiconductor Components (2 x 1.75 hours)

- MC

1 Design Office module (2 x 3.5 hours), based on the use and improvement of a simulation model (PLECS software):

- + Study of the architecture and implementation of the control system for a drive (permanent magnet synchronous machine)
- + Study and dimensioning of the filtering stage (DC side of the inverter)
- + Study of the reversibilities of the current drawn by the inverter from the DC source
- + Identification of the instability phenomenon and dimensioning of a stabilizing solution
- + Study of the losses generated in the semiconductor components constituting the inverter's switching cell
- + Analysis of the datasheet for a SiC MOSFET and Si IGBT power transistor
- + Dimensioning of the number of power modules to be used based on a target operating point
- + Use of PLECS models of transistor and SiC and Si diode losses
- + Dimensioning of the heat sink and thermal simulation of the assembly

Pre-requisites

- + Understanding of switching cells and connection functions; Static and dynamic characteristics of semiconductor components (2A-NRJ course: N7EE02A)

+ concepts of switching and conduction losses in semiconductor components (2A-NRJ course: N7EE02A - Energy approaches to CVS design)

Mechanical design of actuators and generators



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE28C
- **Open to exchange students:** Yes

Presentation

Objectives

The course 'Mechanical Design of Actuators and Generators' aims to provide students with the skills necessary to design and optimise the mechanical aspects of actuators and generators used in electromechanical systems.

Description

Students will learn to analyse mechanical and thermal constraints, as well as select appropriate materials and geometries to ensure device performance, reliability and durability. Emphasis will be placed on modelling forces, torques and vibrations in actuators, as well as techniques for dimensioning rotors, stators and other mechanical components. Students will also explore the integration of electrical and mechanical aspects into design to maximise machine efficiency. Finally, through case studies and practical projects, they will apply this knowledge to real-world industry problems, thereby strengthening their ability to design actuation and generation systems suitable for a variety of applications.

Pre-requisites

None

Introduction to CAD



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE28D
- **Open to exchange students:** Yes

Presentation

Objectives

The 'Introduction to CAD' design office aims to introduce students to the fundamentals of Computer-Aided Design (CAD) using Autodesk Inventor software.

Description

Students will learn how to design 3D models of complex parts and assemblies, mastering parametric modelling tools and the creation of associated technical drawings. Emphasis will be placed on using the software's features to perform stress, motion and interference simulations to ensure the viability of designs. Students will also learn about model version management, tolerance analysis and manufacturing preparation processes. Finally, through practical projects, they will have the opportunity to apply these skills to real industrial projects, thereby developing their ability to use CAD software professionally and efficiently.

Pre-requisites

None

Electric Generators



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE28E
- **Open to exchange students:** Yes

Presentation

Objectives

The aim of the 'Electric Generator' design office is to enable students to design and develop an innovative electromechanical system using an exercise bike as an electricity generator.

Description

Students will learn how to size and integrate the necessary components, such as alternators, rectifier circuits and energy storage systems, in order to produce electrical power from the mechanical movement of the bicycle. The focus will be on optimising the energy efficiency of the generator, managing the energy produced and adapting the control systems to ensure maximum efficiency. Students will also address the mechanical and ergonomic aspects of adapting the exercise bike, while taking into account practical constraints such as durability and safety. Finally, through prototyping and testing phases, they will apply their technical skills to create a functional generator suitable for practical applications such as recharging electronic devices.

Pre-requisites

- Modelling of machines seen from terminals
- Analytical modelling of machines
- Numerical modelling of machines seen from terminals
- Optimisation methods

- CAD
- Basic static conversion circuit

ARCHITECTURES OF MECHATRONIC SYSTEMS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
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Semester
Automne

In brief

- > **Ametys Code:** N9EE29
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Multidimensional Systems	Matière				
Electric actuator control strategy	Matière				
TER Electric Actuator Control	Matière				
Electromagnetic compatibility	Matière				
Filtering estimation	Matière				

Electric actuator control strategy



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE29A
- **Open to exchange students:** Yes

Presentation

Objectives

The main objective is to develop expertise in the field of torque, speed and position control strategies for three-phase electric machines operating in their respective contexts (land transport, aeronautics, space, maritime, and industry, etc.). Operation in the four quadrants of the torque-speed plane is explored, with particular emphasis on the design of control laws and associated observers.

Description

Starting from a common foundation, highlighting the basic procedures for modelling electrical machines, the course branches into two equally important areas devoted respectively to synchronous machines and asynchronous machines – induction machines:

Synchronous machines:

- Representation of synchronous electrical machines – Model

 - Equation formulation, assumptions

 - Three-phase and two-phase representation

 - Non-sinusoidal machine

 - Torque ripple (origins)

- Conventional synchronous machine control

 - Scalar control

 - Conventional control

- Advanced control of synchronous machines
 - Improvement of torque quality
 - De-fluxing of magnet machines
 - Control without mechanical sensors

Asynchronous induction motor (AIM), direct and inverse models

- o Power supply modes for a three-phase squirrel-cage asynchronous motor – specifications
- o Modelling of the three-phase AIM, definition of parameters, simplifying assumptions
- o Three-phase – two-phase transformations, power conservation vs amplitude conservation

Estimators, Observers – indirect sensors of a cage MAS

- o Deterministic estimation/observation of flux
- o Stochastic observations – Kalman flux filter
- o Rotational speed observations, partial and global methods

Indirect and direct controls of a cage-type ASM

- o Linear scalar and vector controls
- o Non-linear controls with sliding mode and exact linearisation

Control of a doubly fed asynchronous machine (DFAM)

- o Dual vector control – naval propulsion

Rotor control – turbomachinery/pumping

Pre-requisites

Electromagnetic modelling of machines: N7EE03B

Modulation and filtering of voltage inverters: N7EE04D

Synthesis of correctors and control architectures: N7EE05C

State space: N8EE13A

Converter control: N8EE15C

Machine control: N8EE15D

ZOE powertrain project: N8EE1

TER Electric Actuator Control



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE29B
- **Open to exchange students:** Yes

Presentation

Objectives

- 1) Develop a methodology for designing control architectures for three-phase electric machines: from modeling the machine under study to designing the nested scalar and vector control architecture.
- 2) Acquire the ability to independently develop an engineering approach to address an electric machine control issue while meeting the requirements of a specification.
- 3) Design an appropriate control architecture for the machine under study, including voltage control of the converter, a current control loop with controlled performance, a torque control strategy, and even a speed control loop.

Description

Format: The study and research topic (TER) "Control of Electric Actuators" is primarily a TER. Within this framework, an open-ended problem is posed for which there is no single answer. In order to develop students' ability to methodically design an approach to solve this problem, teaching is conducted in a semi-supervised mode. This gives students the opportunity to explore different avenues independently.

Theme: The problem to be solved involves designing a control architecture for simulating an electric actuator (three-phase, synchronous, or asynchronous machine). This design implements a comprehensive approach of progressive complexity aimed at designing each control loop one after the other in an interlocked manner. For each loop, based on a given set of specifications, the first step consists of modeling the behavior of the system to be controlled before moving on to the design of the associated controller based on the "inverse model" principle. The electrical model of the converter-machine system in steady state allows the analysis of operating limits in the torque-speed plane and helps in the development of torque control strategies, which is the final step in the

control architecture. The operating performance obtained for the system as a whole is then quantified and analyzed according to the different design choices for the control loops and the selected torque control strategy.

Pre-requisites

Course "N8EE15C: Converter Control,"

Course "N8EE15D: Machine Control,"

Course "N8EE15F: Design Elements of CVS/Machine Associations"

Course "N9EE29A: Electric Actuator Control Strategy,"

Filtering estimation



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE29D
- **Open to exchange students:** Yes

Presentation

Objectives

The objective of this course is to introduce the Kalman filter and its variants as a tool for estimating the state of a dynamic system in the presence of measurement noise, and for filtering the measurements.

Description

- Statistical analysis of the behavior of dynamic systems subjected to random disturbances.
- Bayesian estimation and optimal filtering equations
- Kalman filtering algorithms and their variants (extended Kalman filter and unscented Kalman filter).
- Filter properties and tuning.
- Selection and development of a model for filter synthesis based on objectives
- Application to engine load estimation,
- Application to sensorless motor control.

Pre-requisites

- Analog and Digital Electronics, RF and Microwave Electronics
- Electromagnetism and Propagation Phenomena in Free Space and Guided Waves
- Component Physics, Integrated Circuits, Packaging, Printed Circuit Boards (PCBs)

- Power Electronics and Converters

APPLIED MECHATRONICS



ECTS
5 credits



Component
École Nationale
Supérieure
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d'Informatique
d'Hydraulique
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Semester
Automne

In brief

- **Ametys Code:** N9EE30
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
TER Advanced Control (EMA)	Matière				
Elastic metamaterials and actuators for space (Universeh)	Matière				
Winding techniques for electrical machines	Matière				
System Monitoring and Diagnostics	Matière				

TER Advanced Control (EMA)



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE30A
- **Open to exchange students:** Yes

Presentation

Objectives

- 1) Develop a holistic methodology for designing control architectures: from theoretical system modeling to the implementation of controllers on real-time computers.
- 2) Acquire the ability to independently develop an engineering-type approach to address a control issue while meeting the requirements of a specification.
- 3) Independently acquire knowledge and expertise from technical documentation and scientific literature, then apply it to solve the problem at hand.

Description

Format: The study and research topic (TER) "Advanced Control" is primarily a TER. In this context, an open-ended problem is posed, for which there is no single answer. In order to develop students' ability to methodically design an approach to solve this problem, teaching is conducted in a semi-supervised manner. This gives students the opportunity to explore different avenues independently.

Theme: The problem to be solved involves designing a control law to achieve positional control of a translator-type electromechanical system (a system designed to move loads, as found in various industrial sectors). This design implements a comprehensive approach which, based on a given set of specifications, begins with modeling the system to be controlled. Based on this model, initial conventional controllers are developed in simulation, then their ability to meet the specifications is quantified and analyzed. More advanced controllers are then designed and studied to assess whether they provide a better response to the specifications. Among the various controllers analyzed, a choice must be made as to which one will then be discretized for real-

time implementation on the actual device. Experimental validation on the translator is the final step, allowing for final adjustments to the controllers in relation to the required performance to be achieved.

Pre-requisites

- Methodologies for modeling dynamic systems for control purposes (multiple courses within the Energy program),
- Synthesis of P, PI, PID, and other types of controllers, and selection of the synthesis method based on the characteristics of the system to be controlled (in conjunction with the course "N7EE05C: Synthesis of Controllers and Control Architectures"),
- Modeling of systems in state space (Course "N8EE13A: Analysis and synthesis of systems in state space"),
- Synthesis of discrete controllers (in conjunction with the Course "N7EE05B: Sampled systems"),

Elastic metamaterials and actuators for space (Universeh)



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE30B
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand basic wave phenomena and interactions in complex materials
- Understand the technical constraints associated with the space environment
- Be able to combine and apply dynamic phenomena to obtain the desired response from a structure
- Understand the concepts of mechanical impedance and multiple scattering
- Understand the design principles of metamaterials and be able to apply them to a specific application
- Understand the differences in dynamics between discrete and continuous systems
- Classify different actuation technologies and recognise their capabilities
- Verify application requirements in order to develop specifications
- Develop a multiphysics digital model to design the actuator

- Acquire/improve skills in teamwork, thinking and problem solving, task planning and coordination, breaking down problems into subtasks and interfacing them during work, project planning and verification

Description

Mechatronic space structures require specific solutions in terms of efficiency, robustness and precision for equipment that must operate for several decades without maintenance. In this context, piezoelectric technology combined with specific material properties can provide multi-domain solutions for actuation, mechanical isolation or energy recovery. Elastic metamaterials offer new possibilities in terms of dynamic mechanical response. Metamaterials are a new class of materials with extraordinary properties. In the context of dynamics, they can exhibit negative effective mass and/or stiffness, thus expanding the conventional design space for engineering materials. They can therefore be very interesting for the design of versatile, high-performance devices.

In this course, students will discover the applications of elastic metamaterials for various space mechatronic devices, in particular energy harvesters, actuators, sensors and electromechanical transformers, and will learn how metamaterials can be designed and used to significantly improve the dynamic properties of these systems. Students will have the opportunity to design a device, from theoretical principles to simulations, prototyping and electromechanical testing.

The course comprises eight sessions during which we present the necessary theoretical and practical knowledge, followed by four sessions devoted to a student project focused on the design, assembly and testing of a prototype device. Finally, students participate in an industrial-level project supported and supervised by high-level experts from the space sector.

Winding techniques for electrical machines



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE30D
- **Open to exchange students:** Yes

Presentation

Objectives

Course overview

The course aims to introduce students to the techniques of winding electrical machines. Winding is a very important part of the design phase of an electric actuator. It determines the voltage and current levels of the power supply module on the one hand, and on the other hand also contributes to the harmonic content of the magnetic fields and therefore impacts the efficiency of the machine-converter combination.

SPECIFIC OBJECTIVES

By the end of the course, students will be able to:

- Define a winding configuration for any type of three-phase alternating current machine
- Propose conventional or highly specific windings
- Characterise the harmonic content of the machine's dynamic torque

Description

This course is part of the third-year EMA Electromechanics and Advanced Mechatronics programme, and more specifically the Advanced Mechatronics teaching unit.

Semestre 9 - Energy conversion and electrical networks (CERE)



ECTS
30 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M8FR9UMP
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
POWER SYSTEMS AND NETWORKS	UE				5 credits
System design	Matière				
Static Converters for power network conditioning	Matière				
Static Converters HVDC Networks	Matière				
CVS DESIGN	UE				5 credits
CVS Design	Matière				
CVS control	Matière				
Architecture and Control TER	Matière				
Power Electronic Technology	Matière				
STATIC CONVERTER AND ADVANCED SYSTEMS	UE				5 credits
CVS reliability	Matière				
EMC	Matière				
X. Levels	Matière				
Switching and functional integration	Matière				
ACTUATORS AND GENERATORS	UE				5 credits
Actuator control	Matière				
Actuator Control TER	Matière				
Multidimensional Systems	Matière				
SMARTGRIDS AND MICROGRIDS	UE				5 credits
Autonomous networks	Matière				
Sources, reversibility, storage	Matière				
Smart grids	Matière				
1/2 Themed days	Matière				
SOFT AND HUMAN SKILLS 3EA S9	UE				5 credits
Professional English-LV1-Semestre 9	Bloc				
Anglais Scientifique	Matière				
Choix 2 Anglais Professionnel - 3A	Choix				
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				
CV Entretiens(3EA)	Matière				
Recherche doc.(3EA)	Matière				
CHOIX SHS 3EA S9	Choix				
Entrepreneurship Project	Matière				
Corporate Project and social responsibility	Matière				

POWER SYSTEMS AND NETWORKS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

- **Ametys Code:** N9EE21
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
System design	Matière				
Static Converters for power network conditioning	Matière				
Static Converters HVDC Networks	Matière				

System design



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE21A
- **Open to exchange students:** Yes

Presentation

Objectives

- Learn about the mathematical optimization methods available to engineers for the automatic optimal design of electrical engineering systems
- Raise awareness among future engineers of the systemic approach to the design of electrical energy devices.
- Present a methodological approach to modeling and systemic analysis based on Bond Graph Causal formalism.
- Apply this approach to the field of electrical energy for multi-physical systems and present a set of model classes (static converters, electrical machines, accumulators, etc.) geared toward the systems approach.
- The objective of this design office is to model an electro-hydrostatic actuator (EHA) using the Bond-Graph modeling tool and then replace the power source for this actuator with a fuel cell hybridized with supercapacitors.

Description

1.1 Design by optimization

- Introduction to optimization: Context and importance of optimization / Formulation of an optimization problem / Classification of optimization methods

- One-dimensional optimization methods: Interval methods (dichotomy, Fibonacci, golden ratio) / Interpolation methods / Search for the zero crossing of the derivative - Multidimensional optimization methods: Analytical methods: gradient, accelerated gradient, conjugate gradient, Gauss-Newton, Quasi-Newton (BFGS, DFP) / Geometric heuristics: Gauss-Seidel, Powell, Hooke & Jeeves, Nelder & Mead methods / Stochastic methods: Random Walk, simulated annealing, evolutionary algorithms, nesting methods, particle swarms
- Constrained optimization: Formalization of the Lagrangian / KKT optimality condition / Penalty methods
- Multi-objective optimization: Pareto optimality / Classification of multi-objective optimization methods / Weighting methods, ideal objective, bounded objectives, lexicographic, fuzzy logic
- Applications in electrical engineering: Optimization of a high-voltage connector / Parameter identification / Optimal sizing of a hybrid locomotive / Optimization of a passive wind chain

1.2 System design

- Awareness of the system approach: context, challenges, and characteristics of system design.
- Methodological approach: the Causal Bond Graph, Field of application: modeling in electrical engineering for systemic analysis.
- Examples of models for static converters, electrical machines, storage components, and their combinations

1.3 "BE EHA" system design

- Modeling the EHA using the Bond Graph tool
- Study of system causality - Determination of the transfer function using the established Bond Graph diagram
- Sizing of a hybrid system based on fuel cells and supercapacitors for powering the EHA
- Energy management of the hybrid system: frequency-based approach

Static Converters for power network conditioning



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE21B
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the functions of a voltage inverter connected to an electrical power distribution network. Know how to size a voltage inverter and its filtering components in order to control active and reactive power exchanges or to provide active harmonic filtering.

Description

1.1.1. Res. Energy conditioning

- Reminders about electrical networks: voltage and reactive power regulation.
- Functions of the voltage inverter connected to a network: control and sizing
- Reactive power compensators based on voltage inverters
- Electrical energy quality - Active filtering.

1.1.2. Energy conditioning

CM application project: "converters for energy network conditioning."

Static Converters HVDC Networks



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE21C
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the converter topologies used for high-voltage direct current power transmission.

Know how to size and model an AC/DC conversion station for high-voltage direct current power transmission.

Description

This course presents the conversion topologies used for high-voltage direct current power transmission: thyristor rectifiers, voltage inverters, and modular multilevel converters. A design office project on the dimensioning of an HVDC link illustrates the course content.

Application project for the "converters for HVDC networks" course.

Half-day theme: High-power semiconductors: presentation in the form of a half-day conference given by an industry representative (ABB) on semiconductor technologies suitable for high-power converters.

Pre-requisites

Three-phase thyristor rectifiers, voltage inverters

Rules for combining switching cells and static converters.

CVS DESIGN



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

- **Ametys Code:** N9EE22
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
CVS Design	Matière				
CVS control	Matière				
Architecture and Control TER	Matière				
Power Electronic Technology	Matière				

CVS Design



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE22A
- **Open to exchange students:** Yes

Presentation

Objectives

Know how to analyze specifications in order to determine the number of switching cells required, taking into account:

The fundamental characteristics to be obtained (voltage or current sources, associated frequency range) and the properties of the systems interconnected by the converter to be designed;

Whether the structure is a step-up or step-down converter (in voltage or current);

The reversibilities to be obtained (voltage, current, power) and associated time scales;

The need to introduce passive filtering elements (differential mode)

Know how to connect these cells together and identify their operating constraints, with a view to synthesizing the semiconductors that compose them (see prerequisites)

Identify the degrees of freedom available, through cell control, to drive the operation of the converter; synthesize and size control and regulation solutions that guarantee compliance with the specifications.

Description

Design of static converters, mainly focused on the study of topologies and the construction of circuits that meet specifications

Pre-requisites

Concept of switching cells

Concept of connection function

Synthesis of switching cell semiconductors

Concept of Pulse Width Modulation

All of these prerequisites can be acquired through the course "Energy Approaches to the Design of Static Converters (CVS)" N7EE02A1

Dimensioning of a proportional-integral type corrector

CVS control



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE22B
- **Open to exchange students:** Yes

Presentation

Objectives

Learn control methods to give static converters robust dynamic performance, control energy harvesting, and improve waveforms.

Description

General information on converter modeling

- Issues - dynamic constraints and shape constraints Links between the converter structure and the control structure - The PWM approach to control
- Controller synthesis and linearization
- Characterization of control laws in terms of robustness Energy harvesting - active filtering - harmonic processing / Application examples: PWM inverter and rectifier, multi-cell converter, etc

Architecture and Control TER



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE22C
- **Open to exchange students:** Yes

Presentation

Objectives

Analysis of the structure of an uninterruptible power supply for IT loads.

Breakdown into sub-elements; each group is responsible for studying one of them and must:

- Study how it works,
- Develop sizing criteria
- Propose component values and a choice of control elements and their parameter values, enabling compliance with specifications corresponding to a real device.

The analyses, choices, and sizing carried out are validated by simulation.

The different groups must collaborate to conduct the study of the complete device.

Description

Apply the lessons learned in the "UPS design" and "UPS control" courses.

Know how to analyze the operation of an industrial uninterruptible power supply (UPS).

Learn how to size components and control loops based on given specifications.

Validate the results through simulation.

Pre-requisites

"CVS Design" course

"CVS Control" course / N9EE22B

Power Electronic Technology



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE22D
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand the different technological solutions for implementing passive components in power electronics.
- Understand the thermoelectric limits of passive components in power electronics.
- Understand the equivalent electrical models of passive components in power electronics.

Learn a methodology for sizing and selecting a magnetic component in power electronics.

Description

- Technologies and modeling of magnetic components in power electronics.
- Technologies and modeling of capacitive components in power electronics.
- Case studies.

STATIC CONVERTER AND ADVANCED SYSTEMS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

- **Ametys Code:** N9EE23
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
CVS reliability	Matière				
EMC	Matière				
X. Levels	Matière				
Switching and functional integration	Matière				

CVS reliability



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE23A
- **Open to exchange students:** Yes

Presentation

Objectives

Introduce and illustrate issues relating to reliability, protection, and fault tolerance in conversion structures. Presentation of reliability models and advanced technological solutions.

Description

Nature of constraints (environmental, switching functionality, usage constraints), - Design rules, SOA reminders, extreme conditions for semiconductor components, robustness, protection solutions, - Critical failure conditions, I^2T and destruction energy - explosion, protection solutions, Component aging and technological aspects, main models, diagnostic design using predictive models or sensors, Methodological approach: failure rate, reliability model, reliability diagram, orders of magnitude and numerical applications, Application to conversion structures with and without redundancy, Illustration of secure structures with shared parallel passive redundancy and integrated serial active redundancy

EMC



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE23B
- **Open to exchange students:** Yes

Presentation

Objectives

This course addresses the problem of conducted electromagnetic emissions produced by power converters, one of the frequent causes of EMC non-compliance.

Description

- Presentation of the EMC context;
- Definition of the concept of conducted emissions and experimental illustration;
- Presentation of standard measurement techniques for conducted emissions (e.g., EN55022, CISPR25);
- Identification of sources and modes of propagation of conducted noise produced by a power converter (application to typical switching power supply structures such as buck and flyback converters);
- Presentation of a simplified electrical model for simulating the conducted emissions of a power converter;
- Description of the main EMC filter structures (common mode and differential mode), typical filter components, and their sizing;
- Presentation and illustration of several rules for low-emission design of switching power supplies.

EMC (Electromagnetic Compatibility) application project: Filtering of conducted emissions produced by a flyback AC-DC converter. The objective of this design office is to size the EMC filter at the input of a flyback switching power supply in order to make the product compatible with the EN55022 standard. The study will be based on simulation (IC-EMC and WinSPICE/LTSPICE software) and passive component libraries. The simulation results for filter attenuation will be compared with experimental measurement results.

X. Levels



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE23C
- **Open to exchange students:** Yes

Presentation

Objectives

Understand and analyze the potential advantages of series/parallel connection and understand the difficulties of implementation. Manage degrees of freedom and constraints in multilevel converters.

Study methods of controlling static converters by Pulse Width Modulation (PWM): principles and implementation. Apply to voltage converters. Extend to multilevel converters. Analyze using the 2N vector approach, then multilevel.

Description

X-level converters

- Problem of constraint distribution in series/parallel semiconductor combinations.
- Evaluation of different solutions.
- Multilevel converters (FC, NPC, SMC, etc.).
- Spectral properties.
- Industrial applications.

PWM, Vector Control

- Pulse Width Modulation converters, analysis of single-phase characteristics, determination of three-phase vector control using a systematic approach:
- Vector control of three-phase voltage converters (SVM).
- Multilevel Vector Control – Modulator Optimization – Use of State Machines

Application project for “multilevel converters” and “vector control” CMs. Case study, sizing, and validation by numerical simulation (PLECS

Switching and functional integration



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE23D
- **Open to exchange students:** No

Presentation

Objectives

Identify the essential properties of switching and the design rules for close-coupled control circuits—drivers for chopper, inverter, and switching dimmer structures. Demonstrate the need for a comprehensive analysis involving strong interactions between components, their drivers, and the power circuit.

ACTUATORS AND GENERATORS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

- > **Ametys Code:** N9EE24
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Actuator control	Matière				
Actuator Control TER	Matière				
Multidimensional Systems	Matière				

Actuator control



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE24B
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the fundamental principles of variable speed drives for machines.

- Learn how to calculate control and regulation laws.
- Define estimation and state observation structures.
- Understand the variable speed environment through examples of industrial systems.

The TER illustrates the design and simulation study of a variable speed drive.

Actuator Control TER



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE24C
- **Open to exchange students:** Yes

Presentation

Objectives

Introduce students to the design of a complex simulation using SABER software Study of the control laws for an asynchronous or synchronous actuator.

Description

Simulation study, using SABER software, of an asynchronous or synchronous machine powered by a voltage inverter. The machine's operation (flux, torque, speed) is regulated using a flux-oriented vector control strategy. The voltage inverter, which is initially idealized, is then represented in detail, with different solutions for generating commands. Study of different PWM inverter modulations

SMARTGRIDS AND MICROGRIDS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

- **Ametys Code:** N9EE25
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Autonomous networks	Matière				
Sources, reversibility, storage	Matière				
Smart grids	Matière				
1/2 Themed days	Matière				

Autonomous networks



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE25A
- **Open to exchange students:** Yes

Presentation

Objectives

By the end of the module, students will have covered the elements involved in the design and management of onboard and stationary electrical networks. Particular emphasis is placed on onboard and isolated networks. Various fields are used as examples to illustrate the different concepts presented.

By the end of the course, students will be familiar with the architectures of hybrid systems and the energy/power characteristics of energy sources and storage elements. They will be able to analyze the mission of an energy system, assess the relevance of its hybridization, and design and size a hybrid system. Students will also be able to propose an energy management strategy for a multi-source energy system that respects the intrinsic characteristics of the associated sources.

- Understand the architectures of hybrid energy systems.
- Understand the energy/power characteristics of energy sources.
- Be able to analyze an energy system mission and assess the benefits of hybridization.
- Propose an energy management strategy that respects the energy performance of the energy sources in a hybrid system.
- Understand the basic principles of multi-energy systems.
- Analyze technologies and applications that enable the transition between electricity, heat, cooling, and hydrogen.
- Evaluate the integration of different energy sources to optimize performance and efficiency.

- Develop the ability to design and manage hybrid energy systems.

This Design and Research Office has two objectives:

- The first objective is to familiarize students with PEM (Proton Exchange Membrane) fuel cells: assembly, waking up a fuel cell, and tracing the $V(I)$ polarization curve of a fuel cell. It also involves emulating the behavior of a fuel cell when connected to a boost-type (step-up chopper) or buck-type (step-down chopper) static converter.
- The second objective is to simulate the behavior of a fuel cell stack (several fuel cell units connected in series) connected to a boost- or buck-type static converter.

Description

- Design of Embedded Networks Safety and reliability
- Benefits of hybridization in the operation of an embedded network
- Network safety and reliability
- EMC in electrical networks

Autonomous energy systems – hybridization

In addition to theories relating to hybridization and energy management in multi-source systems, the course is based on several examples of hybrid energy systems drawn from the Laplace laboratory's experience in this field of research. These examples relate in particular to the transport sector (aeronautics, rail, and road).

BE "PAC"

- Experimental implementation of a PEM (Proton Exchange Membrane) fuel cell
- Tracing the polarization curve;
- Emulation of static converters using an active load;
- Simulation of the dynamic behavior of the fuel cell.

Multi-Energy Systems

This course is designed to provide students with an in-depth understanding of the integration and management of different forms of energy, including electrical energy, heat, cooling, and hydrogen. It covers the fundamental principles, current technologies, and practical applications of each possible combination, as well as the links between different types of energy.

Sources, reversibility, storage



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE25B
- **Open to exchange students:** Yes

Presentation

Objectives

The objective of the course is to learn about and understand the operating principles of the main sources of electrical energy and energy storage components.

Description

By the end of the course, students will also be familiar with the static and dynamic models of certain electrochemical components: fuel cells and batteries.

- Understand the operating principles of energy sources and storage devices;
- Be able to use the appropriate model of a source or storage device depending on the problem being studied;
- Be able to identify and compare the different wind energy conversion architectures.

With regard to renewable energies, this course introduces students to the different configurations for converting wind energy. Photovoltaic conversion is not covered in this course (it is covered in the second year).

Smart grids



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE25C
- **Open to exchange students:** Yes

Presentation

Objectives

This four-session course aims to raise students' awareness of the emergence of smart grids by distinguishing them from how networks currently operate.

Description

The concepts of system services (contribution to frequency reserves, adjustment/curtailment, etc.) will be presented, as well as the new degrees of freedom (storage, mass electric mobility, production and consumption predictions, better information (smart meters) for consumption adjustment, etc.) enabling "smart grid management." As the cost to users of these new concepts is essential, an overview of market mechanisms and economic models (investment, operation) will enable students to make the link between energy performance and economic impact. Finally, a few examples of smart grids in island networks and for self-consumption in an eco-neighborhood will highlight these concepts in practice.

1/2 Themed days



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE25D
- **Open to exchange students:** No

Presentation

Description

Presentation, in the form of a half-day conference given by researchers from the LAPLACE laboratory (Light and Matter team), on the challenges of recent lighting technologies and their impact in terms of electrical energy / presentation of power supply solutions (static converters) enabling the best performance of the lighting system

Presentation, in the form of a half-day conference given by SNCF engineers, on the challenges of rail traction and the solutions in terms of electrical energy conversion that can meet these challenges.

Semestre 9 - Artificial Intelligence and Information Processing (IATI)



ECTS
30 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

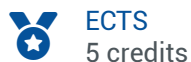
In brief

- **Ametys Code:** M8FRC1JD
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
SIGNAL AND APPLICATIONS	UE				5 credits
Antenna processing	Matière				
Automatic speech processing	Matière				
Audio et musique	Matière				
Satellite navigation	Matière				
AI AND HARDWARE	UE				5 credits
Edge computing	Matière				
Design of NN dedicated to embedded systems	Matière				
ELECTIVE TEACHING UNIT	Bloc				15 credits
ELECTIVE TEACHING UNIT SIA	Choix				
IMAGE - APPLICATIONS	UE				5 credits
Computational imaging	Matière				
Computational medical imaging	Matière				
Teledetection	Matière				
LEARNING AND DECISION	UE				5 credits
Data analysis	Matière				
Unsupervised learning	Matière				
Supervised learning	Matière				
VISION, AUGMENTED REALITY AND APPLICATIONS	UE				5 credits
Computer vision and augmented reality	Matière				
Transversal project	Matière				
ELECTIVE TEACHING UNIT TSE	Choix				
EMBEDDED SYSTEMS	UE				5 credits
System on Chip	Matière				
Architecture and hardware acceleration for DL	Matière				
AI AND SENSORS	UE				5 credits
Intelligent instrumentation chain technology	Matière				
Smart Sensor Project	Matière				
ADVANCED AI	UE				5 credits
Loosely supervised learning, RNN	Matière				
Data analysis 2 and classification	Matière				
SOFT AND HUMAN SKILLS 3EA S9	UE				5 credits
Professional English-LV1-Semestre 3	Bloc				
Anglais Scientifique	Matière				
Choix 2 Anglais Professionnel - 3A	Choix				
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				
CV Entretiens(3EA)	Matière				
Recherche doc.(3EA)	Matière				
CHOIX SHS 3EA S9	Choix				
Entrepreneurship Project	Matière				
Corporate Project and social responsibility	Matière				

SIGNAL AND APPLICATIONS



In brief

- **Ametys Code:** M34HOIQ4
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Antenna processing	Matière				
Automatic speech processing	Matière				
Audio et musique	Matière				
Satellite navigation	Matière				

Antenna processing



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOIVT
- **Open to exchange students:** Yes

Presentation

Objectives

This course aims to present adaptive multi-sensor processing methods that enable the best possible recovery of a signal of interest from noise. The course is illustrated through the application of an antenna array and beamforming.

Description

The course includes a theoretical part presenting the main application, formalising the signal model and the different beamforming methods (conventional and adaptive). In a second stage, in groups of 2-3, learners study certain methods using a syllabus and codes provided. Each group must present a brief summary of these methods, including a critical analysis.

Pre-requisites

Applied mathematics (linear algebra, optimisation), statistics.

Automatic speech processing



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOJ05
- **Open to exchange students:** Yes

Presentation

Objectives

After covering the fundamentals of acoustic signal analysis, theoretical models of speech recognition are explored in depth in order to acquire the knowledge needed to tackle the industrial challenges of tomorrow.

Audio et musique



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOJ6M
- **Open to exchange students:** Yes

Presentation

Objectives

Discover tools for processing and generating audio signals, particularly for restoration (noise reduction, click removal, remixing) and music synthesis (physical models, generative AI).

Description

The course is structured as follows:

Lecture 1: Audio signal denoising (click removal, background noise reduction)

Lecture 2: Non-negative matrix factorisation (NMF) and its application to audio source separation

CM3: Physical models for music synthesis

CM4: Overview of AI methods for audio signal processing

Practical work: Interpolation of audio signals for click removal

Project: Writing a presentation document on Shazam, Audionamix or Spotify.

Pre-requisites

Statistical signal processing, time-frequency analysis, machine learning.

Satellite navigation



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

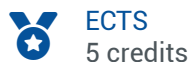
- **Ametys Code:** M34HOJBE
- **Open to exchange students:** Yes

Presentation

Objectives

This module aims to formulate the problem of satellite positioning and navigation, the solutions to this problem, and to provide an overview of the main architectures of navigation systems.

AI AND HARDWARE



In brief

- **Ametys Code:** M34HOK7A
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Edge computing	Matière				
Design of NN dedicated to embedded systems	Matière				

Edge computing



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOKCE
- **Open to exchange students:** Yes

Presentation

Objectives

This module describes data processing methods that can be deployed locally, as close as possible to the end users of the targeted applications.

Design of NN dedicated to embedded systems



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOKJ5
- **Open to exchange students:** Yes

Presentation

Objectives

This module provides a general methodology for designing neural networks that can be embedded in digital systems.

ELECTIVE TEACHING UNIT



ECTS
15 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34H09DA
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
ELECTIVE TEACHING UNIT SIA	Choix				
IMAGE - APPLICATIONS	UE				5 credits
Computational imaging	Matière				
Computational medical imaging	Matière				
Teledetection	Matière				
LEARNING AND DECISION	UE				5 credits
Data analysis	Matière				
Unsupervised learning	Matière				
Supervised learning	Matière				
VISION, AUGMENTED REALITY AND APPLICATIONS	UE				5 credits
Computer vision and augmented reality	Matière				
Transversal project	Matière				
ELECTIVE TEACHING UNIT TSE	Choix				
EMBEDDED SYSTEMS	UE				5 credits
System on Chip	Matière				
Architecture and hardware acceleration for DL	Matière				
AI AND SENSORS	UE				5 credits
Intelligent instrumentation chain technology	Matière				
Smart Sensor Project	Matière				
ADVANCED AI	UE				5 credits
Loosely supervised learning, RNN	Matière				
Data analysis 2 and classification	Matière				

ELECTIVE TEACHING UNIT SIA



Component

École Nationale
 Supérieure
 d'Électrotechnique
 d'Électronique
 d'Informatique
 d'Hydraulique
 et des
 Télécommunications

In brief

- **Ametys Code:** M34H09GZ
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
IMAGE - APPLICATIONS	UE				5 credits
Computational imaging	Matière				
Computational medical imaging	Matière				
Teledetection	Matière				
LEARNING AND DECISION	UE				5 credits
Data analysis	Matière				
Unsupervised learning	Matière				
Supervised learning	Matière				
VISION, AUGMENTED REALITY AND APPLICATIONS	UE				5 credits
Computer vision and augmented reality	Matière				
Transversal project	Matière				

IMAGE - APPLICATIONS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34H09LR
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Computational imaging	Matière				
Computational medical imaging	Matière				
Teledetection	Matière				

Computational imaging



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34H09QB
- **Open to exchange students:** Yes

Presentation

Objectives

This course focuses on the design of numerical methods dedicated to solving inverse problems in imaging. Students will explore a wide range of tools used at each stage of this process: from modelling image formation processes to formalising inverse problems, including issues related to discretisation. Particular attention will be paid to the links between these different components and how they work together to design methods that are both robust and effective.

Description

The course consists of six lectures (with time devoted to exercises) and two tutorials. The course outline is as follows.

1 Physics of imaging

- 1.1 A generic direct model
- 1.2 Some physics concepts (diffraction, X-ray transform)
- 1.3 Digitisation

2 From continuous to discrete

2.1 General principle

2.2 Efficient matrix-vector products (sparse/banded/Toeplitz/low-rank matrices)

2.3 Discretisation errors

3 Ill-posed inverse problems

3.1 Failure of direct inversions

3.2 Generalised inverses

3.3 Inversion stabilisation (filtering of singular systems)

4 Bayesian formulation of an inverse problem

4.1 The parametric statistics perspective (MAP)

4.2 Examples of observation likelihood

4.3 Approximations of data attachments (ℓ_2 -weighted, non-linear transformations, pre/post-processing)

5 Examples of regularisation functions

5.1 Tikhonov

5.2 Total variation

5.3 Parsimony in a basis

Pre-requisites

Algebra, Analysis, Statistics, Introduction to inverse problems, Optimisation.

Computational medical imaging



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34H09V0
- **Open to exchange students:** Yes

Presentation

Objectives

This module provides an overview of the main methods used in medical imaging and the associated image processing techniques.

Teledetection



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34H09ZP
- **Open to exchange students:** Yes

Presentation

Objectives

- Install the software and libraries required for remote sensing processing.
- Apply geoprocessing (including OTB).
- Adjust the display configuration of a multiband image to highlight land uses of interest.
- Identify the characteristics of an image in a GIS.
- Classify a multi-band remote sensing image in an 'expert' manner based on an analysis of the image's spectral dynamics.
- Classify a multi-band remote sensing image in a supervised manner using OTB and estimate its quality without bias using a confusion matrix and derived indices.

Improve the topological or statistical quality of a classification using post-processing.

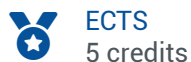
Description

This course covers the physical basics of remote sensing, the format of data used in remote sensing, and how to use it in a GIS. All tutorials will be conducted using QGIS software and the OTB library, both of which are free and can be used on personal computers. The sessions are organised as lectures and tutorials, with theoretical sequences alternating regularly with guided practice. Independent study sessions allow students to consolidate what they have learned through new case studies. Depending on each student's progress, flexible components may be added to the teaching sequence.

Pre-requisites

None

LEARNING AND DECISION



In brief

- **Ametys Code:** M34HOAVS
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Data analysis	Matière				
Unsupervised learning	Matière				
Supervised learning	Matière				

Data analysis



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOB0L
- **Open to exchange students:** Yes

Presentation

Objectives

This course provides an introduction to two distinct data analysis tools: Gaussian processes and optimal transport. First, we will study Gaussian processes, which are used to model and predict functions from data. Next, we will look at optimal transport, which allows us to define distances between probability distributions. This mathematical tool provides a natural framework for taking into account the underlying geometry of data that can be represented as probability distributions (discrete and continuous).

Description

This course is divided into two independent parts: Gaussian processes and optimal transport. For each of these parts, two lectures followed by a tutorial will introduce the tools and teach how to use them, then two practical sessions will allow students to put the tools proposed for data analysis into practice. Assessment for this subject will be based on a final graded practical session and an examination.

Pre-requisites

Have taken courses in probability and have some knowledge of image processing.

Unsupervised learning



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOB5T
- **Open to exchange students:** Yes

Presentation

Objectives

The objectives of this course are:

- to introduce the concept of unsupervised learning and the various objectives that motivate this approach in most applications;
- to introduce certain classic unsupervised learning techniques, their motivation, interpretation, advantages and disadvantages;
- to introduce more modern techniques based on deep learning models, particularly for data generation.

Description

The course comprises six lectures introducing several unsupervised learning techniques, and seven practical sessions (including three independent sessions) allowing students to implement these techniques. The first part of the course covers two classic partitioning techniques: the k-means algorithm and probabilistic classification using Gaussian mixture modelling. Next, we introduce autoencoders, and finally four generative models based on deep learning: generative adversarial networks (GANs), normalising flows (NFs), variational autoencoders (VAEs) and diffusion models (DMs).

Pre-requisites

Introduction to Deep Learning (IATI S8), Multivariate Analysis (IATI S8), Advanced Statistics (IATI-SIA S8), Computational Statistics (IATI-SIA S8).

Supervised learning



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34H0BC7
- **Open to exchange students:** Yes

Presentation

Objectives

This module reviews conventional statistical methods for solving supervised learning tasks, such as classification. It also introduces more recent methods based on deep neural networks.

VISION, AUGMENTED REALITY AND APPLICATIONS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- > **Ametys Code:** N9EN17
- > **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Computer vision and augmented reality	Matière				
Transversal project	Matière				

Computer vision and augmented reality



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EN17A
- **Open to exchange students:** Yes

Presentation

Objectives

This course covers the notions of calibration, interest point detection (in mono or multi-resolution), matching (global and local) and tracking. In addition, you will learn about the well-known SIFT (Scale Invariant Feature Transform) approach and a classical KLT (Kanade-Lucas-Tomasi) tracking approach.

Description

This part is composed of 2 reversed classroom lessons in order to allow the learner to be more active in his learning. Then, 4 practical works illustrate the notions of detection and matching discussed in class in order to build a mosaic of images. This subject will be evaluated via an online course questionnaire and an exam on paper as well as a grade for the practical work. This allows a continuous evaluation of the acquired knowledge.

Pre-requisites

To have followed the second year course Image, Modeling and Rendering or to have notions of image processing and segmentation.

Transversal project



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EN17C
- **Open to exchange students:** Yes

Presentation

Objectives

The objective of this subject is to approach a transversal project access on multimedia in an innovative and active way via a PPA (Problem and Project Based Learning). The subjects can cover the subjects of this UE (Vision and Augmented Reality) but also any other subject of the course approached in the other UE. Examples of past topics are: virtual visit of a museum, object detection and recognition applied to a video game, estimation of optimal trajectory in a video game.

Description

This subject allows to approach a specific application in order to confront the elements studied in courses and practical works with a concrete application, and to deepen the learning related to these various concepts. This project, carried out in groups, will be evaluated in the form of a report, presentation, report and peer evaluation. There will also be an individual online evaluation.

Pre-requisites

No prerequisites, but having taken PBL (Problem-Based Learning and Projects) in 2A Multimedia is a plus.

ELECTIVE TEACHING UNIT TSE



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Amety's Code:** M34HOEK0
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
EMBEDDED SYSTEMS	UE				5 credits
System on Chip	Matière				
Architecture and hardware acceleration for DL	Matière				
AI AND SENSORS	UE				5 credits
Intelligent instrumentation chain technology	Matière				
Smart Sensor Project	Matière				
ADVANCED AI	UE				5 credits
Loosely supervised learning, RNN	Matière				
Data analysis 2 and classification	Matière				

EMBEDDED SYSTEMS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOEP5
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
System on Chip	Matière				
Architecture and hardware acceleration for DL	Matière				

Architecture and hardware acceleration for DL



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

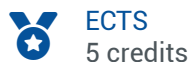
- **Ametys Code:** M34HOEV3
- **Open to exchange students:** Yes

Presentation

Objectives

This module provides an advanced methodology for designing elementary neural network functions using high-level synthesis (HLS) tools for optimal integration into an embedded system.

AI AND SENSORS



In brief

- **Ametys Code:** M34HOFLZ
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Intelligent instrumentation chain technology	Matière				
Smart Sensor Project	Matière				

Intelligent instrumentation chain technology



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOFQR
- **Open to exchange students:** Yes

Presentation

Objectives

This module describes the different components of an intelligent instrumentation chain (from the sensor to the information processing system) and the technologies available to implement them (analog, digital, optical).

Smart Sensor Project



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

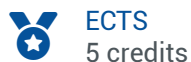
- **Ametys Code:** M34HOFX9
- **Open to exchange students:** Yes

Presentation

Objectives

This module introduces the design and optimization of intelligent instrumentation chains through high-level modeling of each component.

ADVANCED AI



In brief

- **Ametys Code:** M34HOGJY
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Loosely supervised learning, RNN	Matière				
Data analysis 2 and classification	Matière				

Loosely supervised learning, RNN



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** M34HOGOQ
- **Open to exchange students:** Yes

Presentation

Description

This course is divided into two parts; the first will cover recurrent neural networks for processing sequential data, as well as an introduction to Transformer architectures. The second, independent part will present recent advances in weakly supervised learning: self-supervised learning (autoencoders, contrastive methods), semi-supervised learning, and generative methods.

Data analysis 2 and classification



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N9EN22G

Semestre 9 - EcoEnergy (EE)



ECTS
30 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

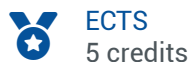
In brief

- **Ametys Code:** M8FRCWEE
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
SYSTEMIC DESIGN	UE				5 credits
System modeling in Bond Graph	Matière				
Eco-design and LCA	Matière				
Hydrogen supply chain	Matière				
Optimization of energy processes and systems	Matière				
SMART-GRIDS	UE				5 credits
Decentralized, embedded electrical networks	Matière				
Energy Hybridization of Systems	Matière				
Smart grids	Matière				
HYDROGEN VECTOR	UE				5 credits
Hydrogen production	Matière				
Hydrogen storage	Matière				
Fuel cells and hydrogen applications	Matière				
Electrochemistry	Matière				
RENEWABLE ENERGIES	UE				5 credits
Wind Power Systems	Matière				
Photovoltaic APP	Matière				
Low-Power Hydroelectric Installations	Matière				
NON ELECTRIC RENEWABLE ENERGIES	Élément constitutif				5 credits
Biofuel systems	Matière				
Valorisation Biomasse Haute Température	Matière				
Renewable heat	Matière				
GENERAL TRAINING	UE				5 credits
Professional English-LV1-Semestre 9	Bloc				
Anglais Scientifique	Matière				
Choix 2 Anglais Professionnel - 3A	Choix				
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				
Themed Day: Energy and Sustainable Development	Matière				

SYSTEMIC DESIGN



In brief

- **Ametys Code:** N9EE34
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
System modeling in Bond Graph	Matière				
Eco-design and LCA	Matière				
Hydrogen supply chain	Matière				
Optimization of energy processes and systems	Matière				

System modeling in Bond Graph



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE34B
- **Open to exchange students:** Yes

Presentation

Objectives

At the end of the course, the student will have mastered the Bond Graph formalism, knowing the various basic elements and the rules for connecting these elements.

They will be able to analyze the various couplings in a system, identifying the system's causal loops.

The student will also be able to determine the transfer function of the system from the Bond Graph model established.

Description

The course introduces the Bond Graph modeling approach. This is a multi-physics approach that makes it possible to model different physical phenomena in the same language, and to take into account the various couplings between the components of a system. This approach is applied in this course to various examples of multi-flow and multi-physics systems.

The course is rounded off by a project involving the modeling of an electro-hydrostatic actuator (EHA) on an A320 aircraft using the Bond Graph approach, and the replacement of the EHA's power source by a fuel cell hybridized with super-capacitors.

Pre-requisites

Basic knowledge of physical systems.

Eco-design and LCA



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE34C
- **Open to exchange students:** Yes

Presentation

Objectives

- Integrate an eco-design approach into the design of energy systems;
- Identify the steps in the Life Cycle Assessment methodology;
- Be able to analyze and critique a life cycle assessment that has already been carried out;

Know how to apply the life cycle assessment method to the study of an energy system.

Description

Introduction: from life cycle assessment to LCA, ISO 14040 standards

- General principle of LCA
- Presentation of the four stages of LCA:

1-Definition of system objectives :

Purpose and scope of the study ;

Product or system function;

Functional unit and reference flows;

Process tree ;

Application examples;

2- Emissions inventories and extractions

Inventory database (e.g. EcolInvent...)

Example of extractions and emissions inventory (alumina production...)

Extraction and emissions inventory calculation method

Energy balance and CO2 balance

3- Environmental impact analysis

Method for interpreting inventory data

Intermediate characterization: calculation of the intermediate impact score

Damage characterization: calculation of damage characterization score

4- Interpretation

- LCA methodology: iterative approach (preliminary assessment or screening, detailed analysis), manual calculations, summary presentation of existing calculation software.

Program and content of the Design Office :

Carrying out a lifecycle analysis of photovoltaic solar panels, using SimaPro software

Presentation of results in the form of a report and oral presentation.

Hydrogen supply chain



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** M4R9Y3LK
- **Open to exchange students:** Yes

Optimization of energy processes and systems



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** M4R9Y0J5
- **Open to exchange students:** Yes

Presentation

Objectives

Optimization issues are becoming increasingly important in energy systems. The aim of this course is to enable students to master the various optimization methods applied to the design and operation of these systems, with a particular focus on multi-objective approaches. Optimization criteria such as cost, energy efficiency, and environmental indicators are often contradictory, making decision-making particularly complex.

The course also introduces Multi-Criteria Decision Making (MCDM) tools, which enable the selection of a solution from a set of "optimal" solutions, thus providing a structured framework for solving the complex problems faced by energy systems.

Description

- Identification of multi-objective optimization problems: Examples of decisions and criteria in energy system optimization.
- Presentation of the main multi-objective optimization methods: Introduction to optimization and decision support approaches adapted to energy systems.
- Identification of relevant optimization strategies: Selection of appropriate approaches based on the specific characteristics of a given problem.
- Formulation of optimization criteria: Definition of technical, economic, and environmental criteria for the optimization of energy systems.

- Case study in a design office: Analysis of a gas turbine combined heat and power system, with problem formulation, multi-objective optimization, and decision-making based on technical, economic, and environmental criteria.

SMART-GRIDS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE35
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Decentralized, embedded electrical networks	Matière				
Energy Hybridization of Systems	Matière				
Smart grids	Matière				

Decentralized, embedded electrical networks



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE35A
- **Open to exchange students:** Yes

Presentation

Objectives

Understand the key issues involved in choosing the architecture and sizing an embedded electrical network in relation to specifications.

Description

At the end of this module, students will know the elements to take into account when sizing an on-board network, such as quality and stability issues, the contribution of hybridization, safety and reliability and EMC.

Pre-requisites

Basic electrical circuits and power balances.

Operation of electrical machines

Energy Hybridization of Systems



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE35B
- **Open to exchange students:** Yes

Presentation

Objectives

By the end of the course, students will be familiar with hybrid system architectures and the energy/power characteristics of energy sources and storage elements.

They will be able to analyze the mission of an energy system, judge the relevance of its hybridization and design and dimension a hybrid system.

The student will also be able to propose an energy management strategy for a multi-source energy system, taking into account the intrinsic characteristics of the associated sources.

At the end of the course, the student will be able to identify the architectures of the hybrid systems and to know the energy/power characteristics of some sources and energy storage elements.

He will be able to analyze the mission of an energy system, to evaluate the relevance of its hybridization and to design a hybrid system.

The student will also be able to propose an energy management strategy of a multi-source energy system by respecting the intrinsic characteristics of the associated sources.

Description

In addition to theories relating to hybridization and energy management of multi-source systems, the course is based on several examples of hybrid energy systems drawn from the Laplace laboratory's experience in this field of research. These examples relate in particular to the transport sector (aeronautics, rail and road).

In addition to the hybridization theory and the energy management of multi-source systems, the course is based on several examples of hybrid energy systems from the Laplace laboratory experience feedback. These examples relate in particular to the transport field (aeronautics, rail and road).

Smart grids



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE35E
- **Open to exchange students:** Yes

Presentation

Objectives

The aim of this 4-session course is to make students aware of the emergence of smart grids, distinguishing them from current grids.

The concept of "smart grids", their characteristics and main challenges are introduced in relation to current power grids. The notions of "system services/grid services" (contribution to frequency/voltage reserves, adjustment/shaving, self-consumption, etc.) are presented. Similarly, new degrees of freedom (storage, massive electric mobility, production and consumption predictions, communicating meters, etc. for consumption adjustment, etc.) enabling "intelligent management of electrical networks" are described. As the cost to the user of these new concepts is essential, an overview of market mechanisms and elements of economic models (investment, operation) will enable students to make a "technical-economic" link between energy performance and economic impact. Finally, a few examples of smart grids, and the detailed example of self-consumption in an eco-neighborhood, will provide a more concrete illustration of these concepts.

Description

smart grids are fully in line with the energy transition. Mass electrification is a key route to the necessary decarbonization of the landscape. After mechanization and information technology (the Internet), smart grids are considered to be the 3rd industrial revolution, as they are the essential link for balancing electricity production and consumption, which will become increasingly precarious with the massive integration of intermittent renewable energies (solar, wind). Smart grids are defined by the idea of integrating electrical infrastructure (energy) with Information and Communication Technologies, in order to provide the flexibility

needed to solve this power balancing problem in reliable conditions (resilient to faults, cyber-attacks, etc.) and at a cost acceptable to consumers.

Pre-requisites

This course is intended to be introductory and requires only fairly general skills in terms of electrical networks, skills taught in 3rd year 3EA, particularly in the CERE and Eco Energie options.

HYDROGEN VECTOR



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** ELP1
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Hydrogen production	Matière				
Hydrogen storage	Matière				
Fuel cells and hydrogen applications	Matière				
Electrochemistry	Matière				

Hydrogen production



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** M4R9Y3TU
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand the challenges of the global hydrogen market and its current production methods.
- Identify low-carbon electrolysis technologies and their applications.
- Model the operation of a water electrolyzer and analyze its efficiency.
- Master the principles of power supply and auxiliary equipment in an electrolysis system.

Description

This module deals with the production of low-carbon hydrogen by electrolysis. It begins by providing an overview of the hydrogen market and conventional production processes. It then examines the different electrolysis technologies, along with their modeling and operational characteristics. The course covers power supply strategies, auxiliary equipment management, and operating constraints. The final section is devoted to a techno-economic analysis of the cost of green hydrogen.

Pre-requisites

Knowledge of electrical engineering and electrochemistry.

Hydrogen storage



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** M4R9Y408
- **Open to exchange students:** Yes

Presentation

Objectives

- Understand the different technologies used for hydrogen storage
- Understand the advantages and disadvantages of each storage technology
- Understand the risks associated with hydrogen and the storage method used
- Understand which storage technology to use depending on the intended application

Description

- Introduction and basic concepts (review)
- Hydrogen storage in gaseous form
- Hydrogen storage in liquid form (LH2)
- Solid hydrogen storage by absorption (Hydrides)
- Solid hydrogen storage by adsorption (Adsorbents)
- Hydrogen storage in organic liquids (LOHC)

- Hydrogen storage underground
- Risks associated with hydrogen
- Introduction to research (disruptive technologies)

Fuel cells and hydrogen applications



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** M4R9Y460
- **Open to exchange students:** Yes

Presentation

Objectives

Fuel Cell Technologies

Characterization by V(I) Polarization and Impedance Spectroscopy

Small-Signal and Large-Signal Modeling of Fuel Cells

Transportation and Stationary Applications

Description

The research and development department focuses on fuel cells and consists of: Evaluating two complementary experimental characterization methodologies: - Dynamic plotting of voltage-current curves. - Impedance spectroscopy. Parameterizing a dynamic model of the PEM fuel cell based on these experimental characterizations. Evaluating the dynamic behavior of the PEM fuel cell in response to disturbances generated by the connection of static converters.

Electrochemistry



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE35D
- **Open to exchange students:** Yes

Presentation

Description

Introduction: Measurable quantities in an electrochemical chain. Two centuries of electrochemical development.

Electrochemical chains at equilibrium. Electromotive force. Electrode potential. Nernst's law. Primary and secondary generators, fuel cells. Capacity, efficiency.

Current-carrying electrochemical chains: Heterogeneous electron transfer. Coupling of heterogeneous electron transfer and solution transport phenomena. Various kinetic regimes. Butler-Volmer law. Limiting current.

- Applications to the development of electrochemical synthesis processes. Applications to corrosion. Applications to the study of generator operation (charging, discharging).

- Overview of various electrochemical methods. Potentiostat.

RENEWABLE ENERGIES



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE36
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Wind Power Systems	Matière				
Photovoltaic APP	Matière				
Low-Power Hydroelectric Installations	Matière				

Wind Power Systems



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE36A
- **Open to exchange students:** Yes

Presentation

Objectives

This course, consisting of four to five sessions, introduces the main principles and concepts involved in converting wind energy into electricity, covering everything from the main components of wind turbines to the architecture of modern onshore and offshore wind farms. The course content includes: History, context, and markets for wind power generation. Key market players; factors driving and hindering the expansion of the industry. Cost and development factors for a wind farm.

Characterization of wind resources, effects of altitude and wake, theoretical factors (Betz limit) on wind power generation and the energy efficiency of wind turbines; mechanical control through blade adjustment, from start-up to safe shutdown.

Composition of electric wind turbines: nacelles with and without speed multipliers;

design elements of wind turbine chains according to their size and technology;

Transient analysis and stable adjustment of the operating point in the torque-speed plane;

Main power conversion architectures for asynchronous and synchronous chains with and without gearboxes, with and without power electronics; Elements for adjusting active and reactive power in these energy chains.

Pre-requisites

Basic knowledge of energy physics (energy/power concepts), basic concepts of electricity and electromechanical conversion (basic concepts of electricity generation).

Photovoltaic APP



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE36D
- **Open to exchange students:** Yes

Presentation

Description

I Solar energy: background and general information

II Photovoltaic conversion :

Radiation in space, on Earth, atmospheric mass

Physical principles, PN junction cell, characteristics, influence of irradiance and T

Photovoltaic cell materials and technologies

III From cell to photovoltaic generator, modularity

Cell associations, series and parallel connection, imbalances and protection

Modeling, simulation, MPPT control

IV Photovoltaic systems

Issues, architectures, energy management (connected, isolated, storage, etc.)

Energy production, solar deposits, characterization, sizing, LCA

Grid-connected systems

Stand-alone systems

V Economic calculations: discount rate, inflation, IRR, LCOE, etc.

Support mechanisms: feed-in tariffs, additional remuneration.

Low-Power Hydroelectric Installations



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE36E
- **Open to exchange students:** Yes

Presentation

Description

Hydropower: different types of structures

Dams, their classification and monitoring

The different turbines and how to choose them according to the structure's characteristics

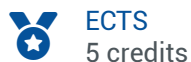
Hydrology of a development, water intake, inflow and outflow structures, turbines and available power, environmental impacts and mitigation measures. Regulations to be applied.

Organization and legislation of hydropower production in France, purchase obligation contracts.

Technical and economic pre-dimensioning of a power plant (BE).

Visit to the EDF Bazacle production site

NON ELECTRIC RENEWABLE ENERGIES



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** ELP2
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Biofuel systems	Matière				
Valorisation Biomasse Haute Température	Matière				
Renewable heat	Matière				

Biofuel systems



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE36B
- **Open to exchange students:** No

Presentation

Description

Introduction to biofuels :

1st generation bioethanol sector:

- Properties and uses of fuel ethanol
- Production process by sector: General diagram, fermentation, feedstock preparation, ethanol separation, prospects for improvement
- Energy and environmental balances
- Sector development (France, Europe, Worldwide)

Biodiesel :

- General data: physical chemistry, standards, reminder of world and European production, production sites.
- raw materials and their preparation.

Chemistry and processes, basic catalysis (Lurgi), heterogeneous catalysis (EsterFIP), introduction to the HVO process.

Biogas :

- Generalities and Production: Biogas, CNG, Biogas fuel
- Biological transformations and processes
- Environmental and economic balances compared with other uses

Biocatalyzed energy systems: biopiles and microbial electrolyzers

Historical background: from research to economic reality for niche markets

Two families of biopiles:

Microbial cells

Enzymatic cells

Hydrogen production by microbial electrolysis

The role of research in the production and use of bioethanol and biodiesel, in relation to energy and environmental aspects

Introduction sur les enjeux des filières biocarburants

Le rôle de la recherche pour la production de bioéthanol

Les biocarburants « deuxième génération »

Innovation dans le domaine des procédés de production

Concept de bioraffineries

Le rôle de la recherche pour la production de biodiesel

Innovation en matière de raffinage et de transformation des huiles végétales

Diversification des matières premières

Adéquation entre motorisation et carburants oxygénés

Bilans énergétiques et environnementaux

Pre-requisites

Basic scientific knowledge: knowing how to interpret a graph, manipulating orders of magnitude, understanding quantities such as yields or balances, notions of processes, bibliographical research, etc.

Valorisation Biomasse Haute Température



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

> **Ametys Code:** N9EE36C

Renewable heat



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** ELP3
- **Open to exchange students:** Yes

Presentation

Description

1. Introduction to Renewable Heat
 - 1.1. Definition and Challenges of Renewable Heat
 - 1.2. Energy Balance and Share of Heat in Final Consumption
 - 1.3. Policies and Regulations (European, French)
 - 1.4. Comparison with Conventional Heat Sources
2. Renewable Heat Resources
 - 2.1. Solar Thermal
 - 2.2. Biomass and Thermal Bioenergy

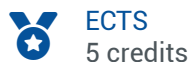
2.3. Geothermal Energy

2.4. Waste Heat and Energy Recovery

3. Techno-economic Evaluation and Environmental Impact

4. Case Studies and Industrial Applications

GENERAL TRAINING



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Amety's Code:** N9EE37
- **Open to exchange students:** Yes

List of courses

	Nature	CM	TD	TP	Crédits
Professional English-LV1-Semestre 9	Bloc				
Anglais Scientifique	Matière				
Choix 2 Anglais Professionnel - 3A	Choix				
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				
Themed Day: Energy and Sustainable Development	Matière				

Themed Day: Energy and Sustainable Development



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EE37A
- **Open to exchange students:** Yes

Presentation

Objectives

Have a broad understanding of energy issues and the energy transition

Description

Beyond teaching about renewable energies (photovoltaic, wind, biogas, etc.), at the heart of our New Energy Technologies program, we want to give students a broader view of energy issues and challenges. To do this, we call on industry specialists in various fields. They give a one-day or half-day presentation, and students write a summary of the presentation, which is then assessed.

Examples of theme days:

JT: Energy transition challenges: Stephan Astier, Professor Emeritus, Toulouse INP

JT: PV: Brigitte Caoussat-Bonnans

JT: Microbial fuel cells

BASSEGUY Regine

JT: Microbial fuel cells

BASSEGUY Regine, CNRS

JT: CO2 capture processes

ALIX Pascal, IFPEN

JT: Nuclear energy

LATGE Christian, CEA

JT: Societal acceptability of renewable energies

VERVIER Philippe Acceptable Futures

JT: Industrial Ecology

Marianne Boix, Ludovic Montastruc

JT: Economic Aspects of Energy

LAFFORGUE Gilles, Toulouse Business School

JT: Economic Analysis of the Electricity Market

LEROYER Yianne, Basque Country Community of Municipalities

JT: Biogas

PRIAROLLO Jeremie, Solagro

JT: Housing

CAPITAINE Loic, Ecozimet

We also visit industrial sites to illustrate the various lessons learned.

Wind and photovoltaic power production site in Ville Franche de Lauragais

Le Bazacle hydroelectric power production site in Toulouse

Smart ZAE SCLE INEO smart grid demonstration platform

Clerverts waste treatment and biogas production site, Organic Vallée

Semestre 9 - Impact Entrepreneurship Low to Deep Tech 3EA



ECTS
30 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

> **Ametys Code:** M8FRIK19

List of courses

	Nature	CM	TD	TP	Crédits
Choix UE Hard Skills 3EA Parcours Impact Entrepreneurship	Bloc				
Choix UE Parc. InSys Parc. Impact Entrepreneurship	Choix				
ADVANCED DIGITAL ELECTRONICS	UE				5 credits
FPGA system design for signal processing	Matière				
Circuit testing and fault simulation	Matière				
POWER MANAGEMENT	UE				5 credits
Microprocessor Power Supply	Matière				
MOSFET Driver Circuits	Matière				
EMC for SMPS	Matière				
FEM Modeling of Integrated passive filters	Matière				
ADVANCED RADIOFREQUENCY ELECTRONICS	UE				5 credits
RF equipment	Matière				
MMIC	Matière				
MEMS	Matière				
ANALOG ELECTRONIC SYSTEMS IN RADIOFREQUENCIES	UE				5 credits
Optoelectronic Components and Circuits	Matière				
Filter Synthesis	Matière				
Integrated photonics	Matière				
Internet of Things	Matière				
DIGITAL SYSTEMS	UE				5 credits
Synthesis strategy	Matière				
EMC for integrated circuits	Matière				
System on Chip	Matière				
ANALOG AND DIGITAL SYSTEMS	UE				5 credits
ADC and DAC	Matière				
Space Embedded Systems Conferences	Matière				
Integration of instrumentation chains	Matière				
Reliability of embedded systems	Matière				
APPROFONDISSEMENT ANALOGIQUE	UE				5 credits
Introduction to Cadence Layout XL / Spectrum	Matière				
Analog ASIC project	Matière				
Choix UE Parc. SysCom Parc. Impact Entrepreneurship	Choix				
ADVANCED RADIOFREQUENCY ELECTRONICS	UE				5 credits
RF equipment	Matière				
MMIC	Matière				
MEMS	Matière				
PROPAGATION PHENOMENA AND RADAR	UE				5 credits
Actual propagation of electromagnetic waves	Matière				
Electromagnetic diffraction analysis / Radar equipment	Matière				
Radar project	Matière				
APPLIED PHYSICS AND NUMERICAL METHODS	UE				5 credits
Electromagnetism and multiscale devices	Matière				
Multiphysics Models	Matière				
Electromagnetism and nanoelectronics	Matière				
Synthesis of High Frequency Equivalent Electrical Circuits	Matière				
HIGH FREQUENCY EMBEDDED SYSTEMS	UE				5 credits
Microwave and Optical Sensors	Matière				
HF optoelectronic components and circuits	Matière				
Internet of Things	Matière				
Passive high frequency devices in waveguide technology	Matière				

Choix UE Hard Skills 3EA Parcours Impact Entrepreneurship



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M34HQEY8

List of courses

	Nature	CM	TD	TP	Crédits
Choix UE Parc. InSys Parc. Impact Entrepreneurship	Choix				
ADVANCED DIGITAL ELECTRONICS	UE				5 credits
FPGA system design for signal processing	Matière				
Circuit testing and fault simulation	Matière				
POWER MANAGEMENT	UE				5 credits
Microprocessor Power Supply	Matière				
MOSFET Driver Circuits	Matière				
EMC for SMPS	Matière				
FEM Modeling of Integrated passive filters	Matière				
ADVANCED RADIOFREQUENCY ELECTRONICS	UE				5 credits
RF equipment	Matière				
MMIC	Matière				
MEMS	Matière				
ANALOG ELECTRONIC SYSTEMS IN RADIOFREQUENCIES	UE				5 credits
Optoelectronic Components and Circuits	Matière				
Filter Synthesis	Matière				
Integrated photonics	Matière				
Internet of Things	Matière				
DIGITAL SYSTEMS	UE				5 credits
Synthesis strategy	Matière				
EMC for integrated circuits	Matière				
System on Chip	Matière				
ANALOG AND DIGITAL SYSTEMS	UE				5 credits
ADC and DAC	Matière				
Space Embedded Systems Conferences	Matière				
Integration of instrumentation chains	Matière				
Reliability of embedded systems	Matière				
APPROFONDISSEMENT ANALOGIQUE	UE				5 credits
Introduction to Cadence Layout XL / Spectrum	Matière				
Analog ASIC project	Matière				
Choix UE Parc. SysCom Parc. Impact Entrepreneurship	Choix				
ADVANCED RADIOFREQUENCY ELECTRONICS	UE				5 credits
RF equipment	Matière				
MMIC	Matière				
MEMS	Matière				
PROPAGATION PHENOMENA AND RADAR	UE				5 credits
Actual propagation of electromagnetic waves	Matière				
Electromagnetic diffraction analysis / Radar equipment	Matière				
Radar project	Matière				
APPLIED PHYSICS AND NUMERICAL METHODS	UE				5 credits
Electromagnetism and multiscale devices	Matière				
Multiphysics Models	Matière				
Electromagnetism and nanoelectronics	Matière				
Synthesis of High Frequency Equivalent Electrical Circuits	Matière				
HIGH FREQUENCY EMBEDDED SYSTEMS	UE				5 credits
Microwave and Optical Sensors	Matière				
Optoelectronic components and circuits	Matière				
Internet of Things	Matière				
Passive high frequency devices in waveguide technology	Matière				

Choix UE Parc. InSys Parc. Impact Entrepreneurship



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M34HQF5E

List of courses

	Nature	CM	TD	TP	Crédits
ADVANCED DIGITAL ELECTRONICS	UE				5 credits
FPGA system design for signal processing	Matière				
Circuit testing and fault simulation	Matière				
POWER MANAGEMENT	UE				5 credits
Microprocessor Power Supply	Matière				
MOSFET Driver Circuits	Matière				
EMC for SMPS	Matière				
FEM Modeling of Integrated passive filters	Matière				
ADVANCED RADIOFREQUENCY ELECTRONICS	UE				5 credits
RF equipment	Matière				
MMIC	Matière				
MEMS	Matière				
ANALOG ELECTRONIC SYSTEMS IN RADIOFREQUENCIES	UE				5 credits
Optoelectronic Components and Circuits	Matière				
Filter Synthesis	Matière				
Integrated photonics	Matière				
Internet of Things	Matière				
DIGITAL SYSTEMS	UE				5 credits
Synthesis strategy	Matière				
EMC for integrated circuits	Matière				
System on Chip	Matière				
ANALOG AND DIGITAL SYSTEMS	UE				5 credits
ADC and DAC	Matière				
Space Embedded Systems Conferences	Matière				
Integration of instrumentation chains	Matière				
Reliability of embedded systems	Matière				
APPROFONDISSEMENT ANALOGIQUE	UE				5 credits
Introduction to Cadence Layout XL / Spectrum	Matière				
Analog ASIC project	Matière				

APPROFONDISSEMENT ANALOGIQUE



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

> **Ametys Code:** M34HPIEE

List of courses

	Nature	CM	TD	TP	Crédits
Introduction to Cadence Layout XL / Spectrum	Matière				
Analog ASIC project	Matière				

Choix UE Parc. SysCom Parc. Impact Entrepreneurship



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M34HQQJL

List of courses

	Nature	CM	TD	TP	Crédits
ADVANCED RADIOFREQUENCY ELECTRONICS	UE				5 credits
RF equipment	Matière				
MMIC	Matière				
MEMS	Matière				
PROPAGATION PHENOMENA AND RADAR	UE				5 credits
Actual propagation of electromagnetic waves	Matière				
Electromagnetic diffraction analysis / Radar equipment	Matière				
Radar project	Matière				
APPLIED PHYSICS AND NUMERICAL METHODS	UE				5 credits
Electromagnetism and multiscale devices	Matière				
Multiphysics Models	Matière				
Electromagnetism and nanoelectronics	Matière				
Synthesis of High Frequency Equivalent Electrical Circuits	Matière				
HIGH FREQUENCY EMBEDDED SYSTEMS	UE				5 credits
Microwave and Optical Sensors	Matière				
HF optoelectronic components and circuits	Matière				
Internet of Things	Matière				
Passive high frequency devices in waveguide technology	Matière				
MICROWAVE CIRCUITS AND ELECTROMAGNETIC COMPATIBILITY	UE				5 credits
Antenna networks	Matière				
Space antennas	Matière				
Aeronautical EMC 1	Matière				
Space Embedded Systems Conferences	Matière				
Microwave power amplifiers	Matière				
Aeronautical EMC 2	Matière				
MODELING	UE				5 credits
Variational methods for solving partial differential equations of physics	Matière				
Integral methods	Matière				
Plasma physics and applications	Matière				

Choix UE Parc. ACISE Parcours Impact Entrepreneurship



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

> **Ametys Code:** M34HQHXJ

List of courses

	Nature	CM	TD	TP	Crédits
SYSTEMS CONTROL, FILTERING AND DIAGNOSTIC	UE				5 credits
Filtering estimation	Matière				
System Monitoring and Diagnostics	Matière				
Multidimensional Systems	Matière				
SYSTEMS OPTIMISATION AND THEIR CONTROL	UE				5 credits
Robust control	Matière				
Optimal Control	Matière				
Combinatorial optimization	Matière				
Opti TER	Matière				
Linear programming and unimodularity	Matière				
Continuous optimization	Matière				
MODELING, ANALYSIS, SIMULATION OF DISCRETE SYSTEMS	UE				5 credits
Modeling and analysis of discrete systems	Matière				
Simulation of discrete event systems	Matière				
Planning and Scheduling	Matière				
Hybrid Dynamic Systems	Matière				
Flexible Workshop TER	Matière				
ADVANCED CONTROLLED SYSTEMS	UE				5 credits
Adaptive and predictive controls	Matière				
Aeronautical systems	Matière				
Robotics: Modeling and Control	Matière				
Advanced Control TER	Matière				
Electrical Systems Control	Matière				
ADVANCED CRITICAL COMPUTING SYSTEMS	UE				5 credits
IT Security	Matière				
IT operational security	Matière				
Safety Testing and Evaluation	Matière				
Development of critical computer systems	Module				

Choix UE Parc.CERE Parcours Impact Entrepreneurship



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M34HQQ5U

List of courses

	Nature	CM	TD	TP	Crédits
POWER SYSTEMS AND NETWORKS	UE				5 credits
System design	Matière				
Static Converters for power network conditioning	Matière				
Static Converters HVDC Networks	Matière				
CVS DESIGN	UE				5 credits
CVS Design	Matière				
CVS control	Matière				
Architecture and Control TER	Matière				
Power Electronic Technology	Matière				
STATIC CONVERTER AND ADVANCED SYSTEMS	UE				5 credits
CVS reliability	Matière				
EMC	Matière				
X. Levels	Matière				
Switching and functional integration	Matière				
ACTUATORS AND GENERATORS	UE				5 credits
Actuator control	Matière				
Actuator Control TER	Matière				
Multidimensional Systems	Matière				
SMARTGRIDS AND MICROGRIDS	UE				5 credits
Autonomous networks	Matière				
Sources, reversibility, storage	Matière				
Smart grids	Matière				
1/2 Themed days	Matière				

Choix UE Parc. EMA Parcours Impact Entrepreneurship



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M34HQKKO

List of courses

	Nature	CM	TD	TP	Crédits
PHYSICS FOR MECHATRONICS	UE				5 credits
Advanced phenomena in electromechanical conversion	Matière				
Introduction to Magnetohydrodynamics	Matière				
Modeling of coupled phenomena	Matière				
NUMERICAL METHODS AND OPTIMISATION	UE				5 credits
Finite element numerical modelling	Matière				
Optimal control	Matière				
Optimised sizing of electrical machines	Matière				
Numerical modelling of machines	Matière				
DESIGN OF ELECTROMECHANICAL SYSTEMS	UE				5 credits
Design elements of static converters	Matière				
Mechanical design of actuators and generators	Matière				
Introduction to CAD	Matière				
Electric Generators	Matière				
ARCHITECTURES OF MECHATRONIC SYSTEMS	UE				5 credits
Multidimensional Systems	Matière				
Electric actuator control strategy	Matière				
TER Electric Actuator Control	Matière				
Electromagnetic compatibility	Matière				
Filtering estimation	Matière				
APPLIED MECHATRONICS	UE				5 credits
TER Advanced Control (EMA)	Matière				
Elastic metamaterials and actuators for space (Universeh)	Matière				
Winding techniques for electrical machines	Matière				
System Monitoring and Diagnostics	Matière				

Choix UE Parc. PN Parcours Impact Entrepreneurship



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M34HQLU0

List of courses

	Nature	CM	TD	TP	Crédits
METHODES NUMERIQUES ET OPTIMISATION-2	UE				5 credits
Optimal control	Matière				
High Performance Computing	Matière				
Simulation Numérique en optique	UE				
Topological Optimisation	Matière				
Finished volumes	Matière				
METHODES NUMERIQUES POUR LES PROBLEMES DE DIFFRACTION	UE				5 credits
Integral methods	Matière				
Electromagnetic diffraction analysis / Radar equipment	Matière				
Integral methods	Matière				
CEM ET MATHEMATIQUES APPLIQUEES	UE				5 credits
Multiphysics Models	Matière				
Variational methods for solving partial differential equations of physics	Matière				
Aeronautical EMC 1	Matière				
Electromagnetic compatibility	Matière				
High Performance Computing	Matière				
PHYSIQUE POUR LA MECATRONIQUE - PN	UE				5 credits
Plasma physics and applications	Matière				
Advanced phenomena in electromechanical conversion	Matière				
Modeling of coupled phenomena	Matière				
Introduction to Magnetohydrodynamics	Matière				
HIGH PERFORMANCE COMPUTING	UE				5 credits
Advanced Languages for programming	Matière				
Advanced Techniques for Scientific computing	Matière				
Meshing, Pre and Post Processing	Matière				

METHODES NUMERIQUES ET OPTIMISATION-2



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Automne

In brief

> **Ametys Code:** N9EE33

List of courses

	Nature	CM	TD	TP	Crédits
Optimal control	Matière				
High Performance Computing	Matière				
Simulation Numérique en optique	UE				
Topological Optimisation	Matière				
Finished volumes	Matière				

Simulation Numérique en optique



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Automne

In brief

> **Ametys Code:** N9EE33B

METHODES NUMERIQUES POUR LES PROBLEMES DE DIFFRACTION



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

> **Ametys Code:** M34HPVWI

List of courses

	Nature	CM	TD	TP	Crédits
Integral methods	Matière				
	Nature	CM	TD	TP	Crédits
Electromagnetic diffraction analysis / Radar equipment	Matière				
Integral methods	Matière				

CEM ET MATHÉMATIQUES APPLIQUÉES



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

> **Ametys Code:** M34HPWDO

List of courses

	Nature	CM	TD	TP	Crédits
Multiphysics Models	Matière				
Variational methods for solving partial differential equations of physics	Matière				
Aeronautical EMC 1	Matière				
Electromagnetic compatibility	Matière				
High Performance Computing	Matière				

PHYSIQUE POUR LA MECATRONIQUE - PN



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

> **Ametys Code:** M34HPY9P

List of courses

	Nature	CM	TD	TP	Crédits
Plasma physics and applications	Matière				
Advanced phenomena in electromechanical conversion	Matière				
Modeling of coupled phenomena	Matière				
Introduction to Magnetohydrodynamics	Matière				

HIGH PERFORMANCE COMPUTING



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

> **Ametys Code:** N9EM03

List of courses

	Nature	CM	TD	TP	Crédits
Advanced Languages for programming	Matière				
Advanced Techniques for Scientific computing	Matière				
Meshing, Pre and Post Processing	Matière				

Advanced Languages for programming



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EM03A
- **Open to exchange students:** No

Presentation

Description

A Python programming project using the Git collaborative development platform for numerical simulation applications in fluid mechanics.

Advanced Techniques for Scientific computing



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EM03B
- **Open to exchange students:** No

Presentation

Description

Introduction to shell language and high-performance scientific computing on supercomputers.

Meshing, Pre and Post Processing



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N9EM03C
- **Open to exchange students:** No

Presentation

Objectives

The aim of this course on meshing is to make students self-sufficient in the creation of geometry (CAD), and in the creation of meshing (structured, unstructured, hexahedral, tetrahedral, polyhedral, hybrid, boundary layer, surface mesh, etc.): basic concepts, role and importance of meshing and its quality in numerical simulation (including HPC), presentation of different meshing algorithms (front advance, empty sphere, etc.). The aim is for students to clearly understand what they are doing when using a mesher, and to critically analyze their meshing in terms of the solver they want to use and the physics to be solved.

The main mesh types (triangular and tetrahedral, quadrangular and hexahedral, hybrid, surface and volume, polyhedral, etc.) are detailed. The algorithms used in free (Salome, Gmsh) or commercial (Ansys tools, Simail) mesh generators are presented.

A set of rules and best practices for mesh generation is outlined, along with the quality criteria associated with different types of mesh.

Particular emphasis is placed on tips for formatting and enhancing the value of simulation results, in order to make the most of the results obtained in this course as well as in the BEI or later in their careers.

Description

- Meshing course
 - Introduction / Examples
 - Numerical methods and meshes
 - Triangular and tetrahedral meshing algorithms

Quadrangular and hexahedral meshing algorithms

Hybrid methods

Surface meshes

Polyhedral meshes

Good meshing practices / Quality criteria

General conclusion on meshes

Meshes available at ENSEEIHT

Geometry construction principles

VISU and POST-PROCESSING course

Introduction

Technical constraints (images and videos)

Creating a quality video

Quality visualization: pitfalls to avoid, formatting, content, making the most of results

- Commercial / free viewing software

Viewing and post-processing tools available at ENSEEIHT

- TUTORIAL

- 4 hours working together on a subject with Salome, the project manager, to validate the basic concepts.

- Mini-projects: In pairs, students carry out mini-projects in which they choose the subject to be meshed (ramjet, arrow, triumphal arch, atmospheric re-entry module, submarine, airship, shell, platypus, etc.), the mesher (Salome, Gmsh, Ansys tools, StarCCM+, simail, comsol, etc.) they want to use and the solver (Code_Saturne, Ansys, StarCCM+, etc.). These mini-projects are assessed in an oral presentation. The meshes generated must have been run on the solver of their choice ...

Choix UE Parc. EE Parcours Impact Entrepreneurship



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M34HQMYP

List of courses

	Nature	CM	TD	TP	Crédits
SYSTEMIC DESIGN	UE				5 credits
System modeling in Bond Graph	Matière				
Eco-design and LCA	Matière				
Hydrogen supply chain	Matière				
Optimization of energy processes and systems	Matière				
SMART-GRIDS	UE				5 credits
Decentralized, embedded electrical networks	Matière				
Energy Hybridization of Systems	Matière				
Smart grids	Matière				
RENEWABLE ENERGIES	UE				5 credits
Wind Power Systems	Matière				
Photovoltaic APP	Matière				
Low-Power Hydroelectric Installations	Matière				
GENERAL TRAINING	UE				5 credits
Professional English-LV1-Semestre 9	Bloc				
Anglais Scientifique	Matière				
Choix 2 Anglais Professionnel - 3A	Choix				
Anglais Clinique	Matière				
Anglais de Cambridge ou Projet	Matière				
Themed Day: Energy and Sustainable Development	Matière				

Choix UE Parc. IATI Parcours Impact Entrepreneurship



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M34HQ09Q

List of courses

	Nature	CM	TD	TP	Crédits
SIGNAL AND APPLICATIONS	UE				5 credits
Antenna processing	Matière				
Automatic speech processing	Matière				
Audio et musique	Matière				
Satellite navigation	Matière				
AI AND HARDWARE	UE				5 credits
Edge computing	Matière				
Design of NN dedicated to embedded systems	Matière				
IMAGE - APPLICATIONS	UE				5 credits
Computational imaging	Matière				
Computational medical imaging	Matière				
Teledetection	Matière				
LEARNING AND DECISION	UE				5 credits
Data analysis	Matière				
Unsupervised learning	Matière				
Supervised learning	Matière				
EMBEDDED SYSTEMS	UE				5 credits
System on Chip	Matière				
Architecture and hardware acceleration for DL	Matière				
AI AND SENSORS	UE				5 credits
Intelligent instrumentation chain technology	Matière				
Smart Sensor Project	Matière				
ADVANCED AI	UE				5 credits
Loosely supervised learning, RNN	Matière				
Data analysis 2 and classification	Matière				
VISION, AUGMENTED REALITY AND APPLICATIONS	UE				5 credits
Computer vision and augmented reality	Matière				
Transversal project	Matière				

SOFT SKILLS 1 - PARTNERSHIPS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** M297M8AN
- **Open to exchange students:** No

Presentation

Description

Deepen your knowledge and skills in entrepreneurship, particularly through partnerships, as part of a low-tech or deep-tech project.

List of courses

	Nature	CM	TD	TP	Crédits
UT ou TBS ou TSM 1 - module 18h	Matière				
UT ou TBS ou TSM 2 - module 18h	Matière				
UT ou TBS ou TSM 3 - module 18h	Matière				

UT ou TBS ou TSM 1 - module 18h



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M297M8FK

UT ou TBS ou TSM 2 - module 18h



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M297M8JC

UT ou TBS ou TSM 3 - module 18h

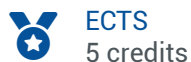


Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M297M8NW

SOFT SKILLS 2 - DESIGN THINKING



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** M297M985
- **Open to exchange students:** No

Presentation

Description

Deepen your knowledge and skills in entrepreneurship, particularly in design thinking, as part of a low-tech or deep-tech project.

List of courses

	Nature	CM	TD	TP	Crédits
Design Thinking 1 - module 15h	Matière				
Design Thinking 2 - module 18h	Matière				
Professional Communication and English - module 21h	Matière				

Design Thinking 1 - module 15h



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

> **Ametys Code:** M297M9C5

Design Thinking 2 - module 18h



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

> **Ametys Code:** M297M9GH

Professional Communication and English - module 21h



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M297M9KX

SOFT SKILLS 3 - PROJET DEEP TECH & APPLICATIONS



ECTS
5 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** M297MA45
- **Open to exchange students:** No

Presentation

Description

Deepen your knowledge and skills in entrepreneurship, particularly through some applications, as part of a low-tech or deep-tech project.

List of courses

	Nature	CM	TD	TP	Crédits
PDT & CU 1 - module 18h	Matière				
PDT & CU 2 - module 18h	Matière				
PDT & CU 3 - module 18h	Matière				

PDT & CU 1 - module 18h



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M297MA7R

PDT & CU 2 - module 18h



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M297MAC3

PDT & CU 3 - module 18h



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M297MAGH

Projet Fin d'Etude 3EA sans Projet Long



ECTS
30 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

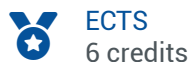
In brief

> **Ametys Code:** M34HQ1PJ

List of courses

	Nature	CM	TD	TP	Crédits
Stage 2A 3EA	Matière				6 credits
PFE 3EA sans PL	Stage				24 credits

Stage 2A 3EA



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M34HQ1T9

PFE 3EA sans PL



ECTS
24 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

➤ **Ametys Code:** M34HQ1YJ

PFE 3EA avec Projet Long



ECTS
30 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

> **Ametys Code:** M34HQ2I6

List of courses

	Nature	CM	TD	TP	Crédits
Stage 2A 3EA	Matière				6 credits
Projet Long 3EA	UE				8 credits
Projet de Fin d'Etudes 3EA	UE				22 credits

Projet Long 3EA



ECTS
8 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Printemps

In brief

> **Ametys Code:** N0EE02A

Projet de Fin d'Etudes 3EA



ECTS
22 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Printemps

In brief

> **Ametys Code:** N0EE02B

MATHEMATICS AND COMPUTER SCIENCE FOR ENGINEER



ECTS
4 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N5AE01
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Math Review	UE				
Computer Science for Engineers	UE				

Math Review



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N5AE01A
- **Open to exchange students:** No

Presentation

Objectives

At the end of this course, students will have the mathematical foundations necessary to confidently tackle the other courses in the program.

Description

During this course, students will review:

- complex numbers,
- integration,
- trigonometric functions,
- the basics of linear algebra,
- differential equations,

- Fourier series.

Pre-requisites

None

Computer Science for Engineers



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N5AE01B
- **Open to exchange students:** No

Presentation

Objectives

The objective of this course is, first of all, to explore algorithmic design tools that allow the development of computer applications using imperative programming. In a second phase, the previously acquired methods are applied in a practical context through the study of the C language. By the end of this course, the student should be able to approach the steps of designing and programming a computer application in C language with a structured methodology.

Description

The module consists of 2 lectures and practical sessions (TD) on algorithmic design aspects. One lecture and practical session is dedicated to the fundamental principles of the C language (pointers and subroutine concepts). A series of 5x1.75-hour practical sessions (BE) is then offered for discovering C programming in the Code::Blocks environment. Finally, an 8x3.5-hour practical session (BE) is proposed, which involves the complete development of a game, from design to programming in C.

Pre-requisites

None

MATHEMATICS AND SCIENTIFIC COMPUTING

 **ECTS**
4 credits

 **Component**
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N5AE02
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Real and Complex Analysis	UE				
Matlab-Simulink	UE				

Real and Complex Analysis



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N5AE02A
- **Open to exchange students:** No

Presentation

Objectives

At the end of this course, students will be able to manipulate complex numbers and functions, recognize holomorphic (analytic) and meromorphic functions, and apply the main results of complex analysis, in particular the residue theorem, to calculate integrals of meromorphic functions. A second objective is to introduce Laplace, Fourier, and Z-transforms. Contour integration techniques will be useful in courses on circuits, control systems, and numerical analysis.

Description

This course comprises 10 lecture-tutorial sessions. During these sessions, we introduce: the complex plane $\mathbb{C}$ and the algebraic and geometric representations of a complex number; complex entire series and their convergence disk; complex functions and the concepts of limit, continuity, and differentiability on $\mathbb{C}$; multiform complex functions and rank determinations; holomorphic functions and Cauchy-Riemann equations; meromorphic functions and Laurent series; complex curvilinear integrals and Jordan lemmas; residue calculus and Cauchy's and Residue Theorems, with applications to integral calculus and real series calculus.

Pre-requisites

Basic concepts in real analysis (limits, real series, convergence, continuity, differentiability, entire series, etc.)

Matlab-Simulink



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N5AE02B
- **Open to exchange students:** No

Presentation

Objectives

A comprehensive introduction to:

The MATLAB® scientific computing environment
Basic modeling techniques and tools for developing SIMULINK® models

Description

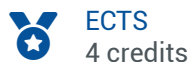
- The MATLAB environment interface
- Entering commands and creating variables
- Analyzing vector and matrix data
- Visualizing vector and matrix data
- Processing data files
- Data types
- Automating commands with scripts
- Writing programs containing loops and conditional branches
- Writing functions

- Creating and modifying Simulink models, and simulating system dynamics
- Modeling continuous, discrete, and hybrid systems
- Modifying solver options for simulation accuracy and performance
- Hierarchy in a Simulink model
- Creating components with subsystems, libraries, and model references

Pre-requisites

No prior knowledge of programming with MATLAB and Simulink software from Mathworks is required.

APPLIED ELECTRICITY



In brief

- **Ametys Code:** N5AE03
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Circuit basics	UE				
Single-phase systems	UE				
Single-phase transformer	UE				

Circuit basics



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N5AE03B
- **Open to exchange students:** No

Presentation

Objectives

Become familiar with the description, composition, and topologies of linear electrical circuits, as well as the characteristic relationships of linear passive components. Master the use of Kirchhoff's laws in circuits and the characteristic equations of linear components. Understand the derivation of first- and second-order differential equations for first- and second-order circuits, as well as the corresponding responses in any time domain and in steady-state sinusoidal conditions. Be aware of international standards in writing and notation.

Description

- 1) Basic concepts: electrical circuits – Electrical quantities and SI units – Kirchhoff's laws – Basic electrical signals
- 2) Circuit elements: characteristic relationships – Linear or linearized model – Current/voltage/power relationship – Electrical or magnetic energy storage
- 3) First-order circuit: general equation – steady-state solution – DC and AC solutions – steady-state sinusoidal solution – Complex notation – Spectral representation

- 4) Second-order circuit: general equation – solution for steady state – solution for DC and AC regimes – solution for steady sinusoidal regime – Complex notation – Spectral representation – Resonances
- 5) Laplace transform applied to the study of circuits in any time regime

Single-phase systems



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N5AE03C
- **Open to exchange students:** No

Presentation

Objectives

Provide students with a scientific background enabling them to understand the concepts of:

- single-phase sinusoidal power supply
- single-phase harmonic pollution;

Description

1- ELECTRICAL POWER IN SINGLE-PHASE SINUSOIDAL OPERATION

1-1. Sinusoidal alternating quantities

1-2. Complex impedances

1-3. Power in single-phase sinusoidal operation

1-4. Power factor correction

2- ELECTRICAL POWER IN NON-SINUSOIDAL OPERATION

2-1. Problems caused by distorting loads: harmonic pollution

2-2. Harmonic analysis of periodic signals

2-3. Power in non-sinusoidal operation

Pre-requisites

node laws/mesh laws;

- concept of impedance; generalized Ohm's law;
- elementary passive dipoles;

Mathematical prerequisites:

- vector construction;
- complex notation of a sinusoidal quantity;
- calculation of an effective value;
- use of Fourier series expansion.

Single-phase transformer



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N5AE03D
- **Open to exchange students:** No

Presentation

Objectives

Provide students with a scientific background that enables them to understand the concepts of single-phase transformers.

Description

Introduction to the single-phase transformer

Perfect single-phase transformer

Equivalent models of the single-phase transformer

Characteristics of the real transformer

Pre-requisites

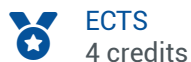
- node laws/mesh laws;

- concept of impedance; generalized Ohm's law;
- elementary passive dipoles;

Mathematical prerequisites:

- vector construction;
- complex notation of a sinusoidal quantity;
- calculation of an effective value;
- use of Fourier series expansion.

ELECTRONIC COMPONENTS AND CIRCUITS



In brief

- **Ametys Code:** N5AE04
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Electronic Components	UE				
Circuit theory	UE				
Basic Electronic Function Project	UE				
Analog circuits	UE				

Electronic Components



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N5AE04A
- **Open to exchange students:** No

Presentation

Objectives

Integrated circuits are made up of active components whose operation is based on the properties of semiconductor materials (mostly silicon). They represent a distillation of science and technological development at the highest level and, at the same time, a factor of socio-economic progress unmatched since the widespread adoption of electricity!

[1] *Sur l'évolution du secteur des semi-conducteurs et ses liens avec les micro et nanotechnologies, Rapport de l'OPECST n° 138 (2002-2003) de M. Claude SAUNIER, fait au nom de l'Office parlementaire d'évaluation des choix scient. tech., déposé le 22 janvier 2003*

Pre-requisites

None, except for the mathematical tools acquired upon entering engineering school.

Circuit theory



Component

École Nationale
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N5AE04B
- **Open to exchange students:** No

Presentation

Objectives

Become familiar with the concept of linear electrical networks and their natural resonance frequencies. Understand multipole descriptions and master the use of quadripoles. Understand conventional methods of linear network analysis. Master the concept of transfer functions and their derivation in the case of a network with one input and one output. Master the technique of decomposition into simple elements in the case of steady-state sinusoidal conditions. Become familiar with the fundamental theorems in linear circuits.

Description

- 1) Methods for analyzing time-invariant linear circuits: Node potential analysis – Mesh current analysis – Time domain and solving linear equation systems in p – Steady-state sinusoidal domain and solving linear equation systems in $j\omega$
- 2) Transfer function: characteristic equation - zeros and poles – Analysis in arbitrary time domain – Analysis in steady-state sinusoidal domain – Simple elements in steady-state sinusoidal domain – Bode diagram
- 3) Fundamental theorems: superposition – Substitution - Thévenin/Norton - Reciprocity – Kennelly – Tellegen – Duality

4) Quadripole: Characteristic matrices – Load line – Generator line – Classification and characteristics of quadripoles - Quadripole combinations

Basic Electronic Function Project



Component

École Nationale
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d'Hydraulique
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Télécommunications

In brief

- **Ametys Code:** N5AE04C
- **Open to exchange students:** No

Presentation

Objectives

Know how to use measuring devices.

Know how to size and implement basic operational amplifier circuits.

- Amplification and filtering functions.
- Comparison function.
- Oscillator function.

Know how to choose an active component for a specific application and how to identify the technological limitations of a system.

Know how to characterize observed signals in terms of time and frequency: time analysis and spectral analysis

- Definition and measurement of the harmonic distortion ratio of a sinusoidal signal
- measurement of a harmonic distortion ratio

Know how to take experimental readings, present them, and analyze them

Description

Project:

To design and implement a device to measure the real part and the imaginary part of an impedance.

Pre-requisites

Lectures and tutorials: Circuit theory

Analog circuits



Component

École Nationale
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d'Électronique
d'Informatique
d'Hydraulique
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Télécommunications

In brief

- **Ametys Code:** N5AE04D
- **Open to exchange students:** No

Presentation

Objectives

- Know how to choose the basic structures for designing a multi-stage amplifier circuit using discrete components based on their intrinsic properties.
- Be able to analyze the basic structures that make up a multi-transistor circuit that has already been designed.

Description

Properties of basic structures (common emitter transistor, common base, common collector): DC bias (static load line), AC amplification (dynamic load line, calculation of voltage gain, influence of the internal resistance of the AC generator on this gain, calculation of input and output impedances).

Concept of active load.

SCIENCES HUMAINES SOCIALES ET JURIDIQUES-S5-FISA



ECTS
4 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

> **Ametys Code:** N5AK06

List of courses

	Nature	CM	TD	TP	Crédits
Careers and Management 1	Matière				
Careers and Management 2	Matière				
Anglais Professionnel-S5-App	Matière				

Careers and Management 1



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N5AK06C
- **Open to exchange students:** No

Presentation

Objectives

Develop key professional competencies to communicate effectively, manage projects and work in international teams.

Description

1 semester of 12 weekly sessions aimed to develop your personal professional project.

Careers and Management 2



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N5AK06D
- **Open to exchange students:** No

Presentation

Objectives

Develop key professional competencies to communicate effectively, manage projects and work in international teams.

Description

1 semester of 12 weekly sessions aimed to develop your personal professional project.

Anglais Professionnel-S5-App



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N5AK06E
- **Open to exchange students:** No

Presentation

Objectives

Perform key oral and written workplace tasks in English.

Description

A semester of 12 weekly sessions to develop English intercultural communication competencies for professional purposes.

COMPANY SEMESTER 5



ECTS
10 credits



Component
École Nationale
Supérieure
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d'Électronique
d'Informatique
d'Hydraulique
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Télécommunications



Semester
Automne

In brief

- **Ametys Code:** N5AE06
- **Open to exchange students:** No

MATHEMATICS AND COMPUTER SCIENCE FOR ENGINEERS



ECTS
4 credits



Component
École Nationale
Supérieure
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d'Électronique
d'Informatique
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Semester
Printemps

In brief

- **Ametys Code:** N6AE01
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Real analysis	UE				
Probabilities and Statistics	UE				
Calculator Structure	UE				

Real analysis



Component

École Nationale
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d'Électronique
d'Informatique
d'Hydraulique
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Télécommunications



Semester

Printemps

In brief

➤ **Ametys Code:** N6AE01A

➤ **Open to exchange students:** No

Presentation

Objectives

Understand the principles of the Laplace and Fourier transforms and know how to use them.

Description

Elements of integration theory are recalled. The Fourier transform is introduced for integrable functions, and its application to other functions is gradually proposed. The properties and calculation rules of the Fourier transform are provided and implemented. Another part of the lesson is devoted to the Laplace and Z transforms. Definitions and calculation rules are given. These concepts are applied in exercises.

Pre-requisites

None

Probabilities and Statistics



Component

École Nationale
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d'Informatique
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Semester

Printemps

In brief

➤ **Ametys Code:** N6AE01B

➤ **Open to exchange students:** No

Presentation

Objectives

This course aims to enable future engineers to build a mathematical model from the observation of a random phenomenon and the collection of experimental or sampling data in hydrology. This process involves researching and selecting the model, precisely adjusting it using observations, and validating it. This model should then allow for a better understanding or analysis of the phenomenon and, where appropriate, lead to decision-making or forecasts. Each model is introduced within an application context related to quality control, reliability, survey sampling, or monitoring of industrial production or an economic factor. Engineers facing such problems in a design office will be able to adapt these models to their specific problem and solve it effectively.

Description

Calculation of the probability of an event during a random experiment; conditional probability; independence. The main univariate models; discrete models: Bernoulli distribution, binomial distribution, Poisson distribution, geometric distribution, hypergeometric distribution; density models: uniform distribution, exponential distribution, gamma distribution, Gaussian distribution, log-normal distribution, Cauchy distribution. Multivariate models; correlation; multinomial distribution, multidimensional Gaussian distribution, Pareto distribution, Cauchy distribution; joint distribution, marginal distributions; independence; change of variables. Tools for model fitting; parameter estimation, unbiased minimum variance estimation, maximum likelihood estimation.

Pre-requisites

Counting. Combinatory. Integration.

Calculator Structure



Component

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Semester

Printemps

In brief

- **Ametys Code:** N6AE01C
- **Open to exchange students:** No

Presentation

Objectives

- Emulate the internal operation of a microprocessor associated with its peripherals
- Visualize the flow of information within the architecture and analyze memory accesses
- Develop programs from a set of instructions implemented in the sequencer

Description

Implementation of a minimal computer system based on an EROS (Etude Rationnelle d'un Ordinateur par Simulation) interface with instruction sequencing analysis and assembly language programming with input/output control.

Pre-requisites

minimal system architecture, Von Neumann architecture, sequential and combinatorial logic, input/output interfaces

ANALOG ELECTRONICS



ECTS
4 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Printemps

In brief

- **Ametys Code:** N6AE02
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Analog Electronics Project	UE				
Electronic Functions	UE				
Analog circuits	UE				

Analog Electronics Project



Component

École Nationale
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d'Électronique
d'Informatique
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Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6AE02A
- **Open to exchange students:** No

Presentation

Objectives

Design a high-gain, relatively wideband voltage amplifier that meets specific specifications.

Design based on the following circuits studied in the "Analog Circuits" and "Electronic Functions" modules:

- Common emitter (degenerate)
- Common collector
- Differential pair and current mirror

Pre-requisites

Analog Circuits Lectures and Tutorials

Electronics Functions Practical Work

Electronic Functions



Component

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Télécommunications



Semester

Printemps

In brief

➤ **Ametys Code:** N6AE02B

➤ **Open to exchange students:** No

Presentation

Objectives

- Use and consolidate the knowledge acquired in semester 5

Passive circuits: know how to use time and frequency domain measurement methods (transient response, resonance frequency, etc.) to determine the characteristics of a passive component or assembly

Active circuits with operational amplifiers: implementation and characterization of active filters of order 2 or higher. Consequences of component technological limitations on assemblies

- Implementation and characterization of transistor assemblies studied in class, Analog Circuits tutorial

Translated with DeepL.com (free version)

Analog circuits



Component

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Semester

Printemps

In brief

- **Ametys Code:** N6AE02C
- **Open to exchange students:** No

Presentation

Pre-requisites

Semiconductor physics and PN junctions; analog circuit fundamentals

LINEAR CIRCUITS AND SYSTEMS



ECTS
4 credits



Component
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester
Printemps

In brief

- **Ametys Code:** N6AE03
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Combinatorial and sequential logic	UE				
Filtering	UE				
Continuous Linear Systems	UE				

Combinatorial and sequential logic



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6AE03A
- **Open to exchange students:** No

Presentation

Objectives

- Know how to convert numbers in the binary system (signed and unsigned numbers)
- Know how to use the main functions of combinational logic (multiplexer, comparator, decoder, etc.) to design and implement combinational functions.
- Know how to define a synchronous sequential system.
- Know how to use state diagram and transition table tools to design and implement basic synchronous sequential functions (counters, shift registers, etc.).
- Know how to use state diagram and transition table tools to design and implement state machines (Moore machines).
- Know how to write the VHDL description of these combinatorial and sequential systems.

Description

Organization:

- Work in groups of 4 to 5 students during lectures and tutorials
- Work in pairs during practicals and projects

Filtering



Component

École Nationale
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6AE03B
- **Open to exchange students:** No

Presentation

Objectives

The objective of this course is to understand the methods of synthesis and design of analog filters.

Description

This course consists of seven parts:

- Analog front-end architecture: Heterodyne and superheterodyne. Role and specification of filters in the system.
- Determination of a partially known filter function: how to find a function or family of functions that meets a known electrical characteristic (either magnitude or phase, real or imaginary parts, even or odd parts).
- LC network synthesis techniques: Cauer, Foster, and Darlington methods.
- Attenuation approximation functions: Butterworth, Chebyshev.
- Design of prototype low-pass filters.
- Frequency transformations: from low-pass prototype to high-pass, band-pass, or band-stop filters.
- Active filters.

Pre-requisites

None

Useful info

Place

➤ Toulouse

Continuous Linear Systems



Component

École Nationale
Supérieure
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6AE03C
- **Open to exchange students:** No

Presentation

Objectives

- Understand the basic principles of continuous linear control
- Know how to model energy systems using circuit formalism regardless of the physical domain (electrical, mechanical, hydraulic, magnetic, thermal)

Description

Introduction to Continuous Linear Control Systems

- Concept of linear systems
- Modeling using transfer functions and block diagrams
- Structure of a control system with feedback, link between the process to be controlled and the signal part

Physical Analogies

- Introduction to physical analogies in energy systems: generalized energy and power variables
- Elements of physical systems: source, dissipative, or energy storage elements (in kinetic or potential form), interconnection elements (generalized mesh and node laws, transformers, and gyrators)
- Causality in physical systems
- Examples of systems: academic cases, level control, position control

Pre-requisites

Circuit fundamentals, differential equations, complex variables

Useful info

Place

➤ Toulouse

ELECTRICAL NETWORKS AND ENERGY CONVERSION



ECTS
4 credits



Component
École Nationale
Supérieure
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d'Électronique
d'Informatique
d'Hydraulique
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Télécommunications



Semester
Printemps

In brief

- **Ametys Code:** N6AE04
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Introduction to Static Conversion	UE				
Switching power supply - Non-isolated structures	UE				
Introduction to Electromechanical Conversion	UE				
Three-phase networks	UE				

Introduction to Static Conversion



Component

École Nationale
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6AE04A
- **Open to exchange students:** No

Presentation

Objectives

At the end of this course, students will be able to understand, simulate, and operate two types of static converters: single-phase voltage inverters and single-phase and three-phase voltage rectifiers.

Description

This course includes lessons on the theory of single-phase inverter operation and control strategies, as well as the principles of single-phase and three-phase uncontrolled (diode) and controlled (thyristor) voltage rectifiers.

These theories are accompanied by two design offices for the simulation of single-phase voltage inverters and controlled and uncontrolled three-phase voltage rectifiers.

Pre-requisites

This subject requires knowledge of the basic elements and theories of electronics and electrical circuits.

Switching power supply - Non-isolated structures



Component

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Semester

Printemps

In brief

➤ **Ametys Code:** N6AE04B

➤ **Open to exchange students:** No

Presentation

Objectives

At the end of this course, students will be able to understand and simulate the operation of a non-isolated DC-DC converter. Two types of choppers are studied: the step-down chopper and the step-up chopper. Students will also be able to build a step-down chopper, perform a temporal and spectral analysis of the electrical input and output quantities, and determine the output characteristics and efficiency of the chopper.

Description

This course includes a lecture on the theory of operation of a non-isolated DC-DC converter. Buck and boost converters are studied with different voltage and current reversibility configurations.

This course is accompanied by a design office for the simulation of buck and boost converters and a project to build a buck converter.

Pre-requisites

This subject requires knowledge of the basic elements and theories of electronics and electrical circuits.

Introduction to Electromechanical Conversion



Component

École Nationale
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Télécommunications

In brief

- **Ametys Code:** N6AE04D
- **Open to exchange students:** No

Presentation

Objectives

- By the end of this course, students will have learned the basic principles of electromechanical energy conversion. They will understand the electrical and magnetic forces at work in most machines and actuators.
- They will have studied electric and magnetic fields and the associated forms of energy.
- They will be able to calculate electrical and magnetic quantities to determine the forces produced.

Pre-requisites

- The basics of electricity
- Calculation and vector operators (div, rot, grad, Laplacian, etc.)
- Cartesian and polar coordinate systems

Three-phase networks



Component

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et des
Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N6AE04C
- **Open to exchange students:** No

Presentation

Objectives

Provide students with a scientific background to understand the concepts of balanced or unbalanced three-phase sinusoidal systems.

Description

- Determination of the connection of a three-phase load;
- Determination of the voltage drop in a transmission line;
- Determination of the current consumed by a three-phase installation;
- Calculus of the power factor of a three-phase installation and power factor correction;
- Study of harmonic pollution in an installation (filtering);
- Calculus of the current in the neutral in the case of an unbalanced load;

· Determination of the connection and the tap setting of a three-phase transformer;- Calculation of losses in a three-phase transformer.

Pre-requisites

Node laws / mesh laws / generalized Ohm's law;- Single-phase sinusoidal regime;- Vectorial construction; complex notation of a sinusoidal quantity; Fourier series expansion.

SCIENCES HUMAINES SOCIALES ET JURIDIQUES-S6-FISA



ECTS
4 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

> **Ametys Code:** N6AK06

List of courses

	Nature	CM	TD	TP	Crédits
Anglais Professionnel-S6-FISA	Matière				
Careers and Management 1	Matière				
Careers and Management 2	Matière				

Anglais Professionnel-S6-FISA



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N6AK06B
- **Open to exchange students:** No

Presentation

Objectives

Develop your professional communication skills by performing routine written and oral communication tasks in English.

Description

One semester of 12 interactive weekly sessions.

Careers and Management 1



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M4RA357R

Careers and Management 2



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M4RA35DY

COMPANY SEMESTER 6



ECTS
10 credits



Component
École Nationale
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d'Électronique
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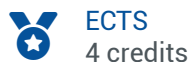


Semester
Printemps

In brief

- **Ametys Code:** N6AE05
- **Open to exchange students:** No

MATHEMATICS AND COMPUTER SYSTEMS



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE01
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Partial Differential Equation	UE				
Modeling and Development of Industrial Systems: Programmed Logic	UE				
Modeling and Development of Industrial Systems—Object-Oriented Modeling and Development	UE				

Partial Differential Equation



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE01A
- **Open to exchange students:** No

Presentation

Objectives

At the end of this course, students will have some knowledge of numerical analysis and discretization of partial differential equations.

Description

During this course, students will study methods for discretizing partial differential equations (finite difference method and finite element method). Examples from electromagnetism will be discussed in the design office.

Pre-requisites

Les rappels de mathématiques.

Modeling and Development of Industrial Systems: Programmed Logic



Component
École Nationale
Supérieure
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE01B
- **Open to exchange students:** No

Presentation

Objectives

Modelling sequential systems and discrete events systems.

Functional sequence modelling level. Finite State machine and Sequential Function Chart approach (SFC). Equivalent logical equations to obtain real time programmable structure executed on Programmable Logic Computer (PLC).

Description

lectures and tutorials

4 practical sessions for implementation, using API equipment, programming software, and various operational components.

Pre-requisites

Combinational logic, sequential logic, operating system, processor operation

Modeling and Development of Industrial Systems— Object-Oriented Modeling and Development



Component
École Nationale
Supérieure
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE01C
- **Open to exchange students:** No

Presentation

Objectives

Introduction to the basic concepts of object-oriented design and programming, illustration of these notions with the C++ language, specification analysis, abstract view of a problem, classification and reuse. Quick overview of other languages (Java) and object-oriented design methods (UML).

Description

The course is divided into five chapters

- Introduction to the basic concepts of object-oriented design and programming
- Main characteristics of object-oriented languages (encapsulation, classification, inheritance, polymorphism, dynamic linking, etc.)
- Basic elements of the C++ programming language (typing, structuring of programs, references, etc.)
- The specificities of the object-oriented in C++ (classification and inheritance, input-output, exceptions, templates)

- Basic concepts of other languages and object methods (quick introduction to Java and UML).

The practical classes give the student the opportunity to understand these concepts and development techniques and master them. The proposed project is focusing more on the design and classification aspect than on complex algorithms.

Pre-requisites

Algorithms, Data Types and Data Structures, Programming in C

Useful info

Contacts

Responsable pédagogique

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DIGITAL SYSTEMS AND DIGITAL SIGNAL PROCESSING



ECTS
4 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE07
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Microprocessors	UE				
Digital Signal Processing	UE				

Microprocessors



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE07A
- **Open to exchange students:** No

Presentation

Objectives

Understand the inner workings of a microprocessor and a microcontroller.

Be able to distinguish between fundamental concepts: sampling, quantization, resolution, memory, bus, instruction cycles, etc.

Be able to describe the architecture of a microcontroller, particularly that of PICs (8-, 16-, and 32-bit families).

Learn to program a microcontroller at a low level:

- * Understanding assembly language,
- * Introduction to C programming for embedded systems.

Be able to configure and use internal peripherals: timers, ADCs, GPIO ports, UARTs, SPIs, interrupts, etc.

Translated with DeepL.com (free version)

Description

The course is a comprehensive introduction to embedded microelectronics.

It covers:

- 1 / The basic principles of digital technology (sampling, quantization, buses, memories).
- 2/ The detailed operation of a microprocessor: arithmetic logic units, control units, execution cycles, and instruction sets.
- 3/ Memories: RAM, ROM, EEPROM, Flash, and their hierarchy.
- 4/ PIC microcontrollers:
 - * Harvard and Von Neumann architectures
 - * Differences between RISC and CISC
 - * Memory organization and interrupt management
 - * Peripherals: I/O ports, timers, CAN (ADC), UART, SPI, etc.
 - * Examples of assembly and C code for PIC18 and PIC24.

This is therefore a theoretical and practical course, focused on understanding hardware and low-level programming.

Translated with DeepL.com (free version)

Pre-requisites

To effectively follow this course, it is recommended that you have:

- * A solid foundation in digital electronics (bits, buses, binary logic).
- * A basic understanding of logic systems and electronic circuits.
- * An introduction to C programming (basic syntax, loops, variables).
- * An interest in embedded systems and the internal workings of processors.

Digital Signal Processing



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE04C
- **Open to exchange students:** No

Presentation

Objectives

Moving from continuous-time signal processing theory to digital signal processing practice.

Description

Lecture-Tutorial 1: Introduction, Review of Fourier Transforms
Lecture-Tutorial 2: Signal Classes and Their Representations
Lecture-Tutorial 3: Continuous-Time Filtering
Lecture-Tutorial 4: Study of a Multi-Path System
Lecture-Lab 5: Advantages of digital technology - sampling
Lecture-Lab 6: Quantization - Discrete Fourier Transform (beginning)
Lecture-Lab 7: Discrete Fourier Transform (continued): zero padding, fast algorithm (FFT)
Lecture-Tutorial 8: Autocorrelation estimation and spectral analysis: periodogram/correlogram, Spectral Power Density
Lecture-Tutorial 9: Review of Z-transform, time-invariant linear filtering, and applications

BE 1 to 5: Spectral analysis and filtering of simulated and real signals using Matlab

Pre-requisites

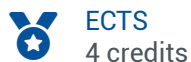
Fourier analysis.

Complex variables, Z-transform.

Probability and statistics.

Matlab programming

STATIC CONVERSION AND THEIR CONTROL



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE03
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Design and implementation of Static Converters	UE				
Closed-loop control of continuous linear systems	UE				

Design and implementation of Static Converters



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE03B
- **Open to exchange students:** No

Presentation

Objectives

- + Understand the principle and circuitry of the switching cell
- + Understand the transformations of electrical quantities performed by the cell and be able to use them on the time scale of instantaneous switching phenomena and at low frequencies
- + Understand the principle and limitations of pulse width modulation.
- + Identify switching cells in a diagram and use this information to identify the degrees of freedom they provide for controlling power transfers
- + understand the causal relationships that govern power transfers through switching cells
- + understand the operating rules of switching cell switches (static and dynamic) and be able to use them to construct the static and dynamic characteristics of switches
- + understand and use the controlled or spontaneous characterization of switching cell switch transitions
- + Be able to size the cell's semiconductor components and associated passive components to control operating conditions

+ Be able to synthesize the semiconductors (and any switching management circuit) necessary to obtain the static and dynamic characteristics identified for the switches

Description

Knowledge is imparted during eight 1 hour 45 minute sessions and assessed in a 1 hour exam.

Certain principles are introduced and certain cases are dealt with during exercise sequences integrated into the lessons, so that students can easily identify the objectives and purpose of the approach.

Pre-requisites

- + Methods for analyzing electrical circuits (Thevenin, Norton, Millman, Kirschoff's laws, etc.)
- + Characteristics and Ohm's laws for reactive components: capacitors, inductors, transformers
- + Semiconductors operating in switching mode: transistors, diodes, thyristors
- + Basic logic circuits

Closed-loop control of continuous linear systems



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE03C
- **Open to exchange students:** No

Presentation

Objectives

Be able to...

- Choose a type of controller suitable for a specification,
- Simplify models and determine their domain of validity,
- Calculate the parameters of a P, PI, Phase-Advance, PID controller using different methods,
- Choose the method and structure of the controller based on the context and specifications,

Description

Interest of the closed loop: open loop, closed loop, proportional correction, stability, accuracy, speed = tough dilemma!, calculation of the proportional controller / specifications

Integral-type controllers: dominant pole compensation method, symmetrical optimum method, 1/10 method, implementation

Derivative-type controllers: calculation of parameters by imposing the bandwidth, by the pole compensation method, implementation.

PID-type controllers: calculation by pole compensation, by PI combination – Phase lead

Experimental methods for tuning PI, PID controllers: Expert tuning, Broida method, Ziegler-Nichols method, and relay method

Control architectures: PI and beyond..., more state variables to control, a bit of anticipation

Context: supporting application

Pre-requisites

- Continuous Linear System, basic calculations with Laplace transform
- Calculations with complex numbers, solving first- and second-order differential equations

ELECTIVE TEACHING UNIT



ECTS

 4 credits



Component

 École Nationale

 Supérieure

 d'Électrotechnique

 d'Électronique

 d'Informatique

 d'Hydraulique

 et des

 Télécommunications

In brief

- > **Ametys Code:** N7AEX
- > **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
OPTION EN: MATERIAL DESCRIPTION LANGUAGES and TR	UE				4 credits
Digital design in VHDL	UE				
VHDL Project	UE				
DSP, Digital Filtering	Élément constitutif				
OPTION ENERGY: ELECTROMECHANIC CONVERSION	Matière				4 credits
Machine Modeling	UE				
Principles and structures of electrical machines	LV2 facultative				

OPTION EN: MATERIAL DESCRIPTION LANGUAGES and TR



ECTS
4 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE04
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Digital design in VHDL	UE				
VHDL Project	UE				
DSP, Digital Filtering	Élément constitutif				

Digital design in VHDL



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE04A
- **Open to exchange students:** No

Presentation

Description

After learning the basics of the language, we will establish the rules for writing digital circuits. We will analyze practical cases to understand the interactions between the behavioral description in VHDL and the implemented digital circuit. We will illustrate this course using FPGA circuits. 80% of the instruction will be delivered using design tools (VIVADO from Xilinx).

Pre-requisites

Basic knowledge of digital circuits: Combinational circuits, Sequential circuits and State machines.

VHDL Project



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE04B
- **Open to exchange students:** No

Presentation

Objectives

- Course illustration: implementation in VHDL of elementary synchronous combinational and sequential functions (counters, registers, multiplexed displays, state machines)
 - Ability to apply the knowledge acquired in lectures and practical sessions to design a sequential system described by a specification: Design, VHDL implementation, and testing phase
-

Pre-requisites

Digital Design Course and Tutorials in VHDL

DSP, Digital Filtering



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** ELP16
- **Open to exchange students:** Yes

Presentation

Objectives

This course introduces the operating principles and basic structures of the main rotating electrical machines used in modern industrial electromechanical and power systems (direct current machines, alternators, induction motors, synchronous motors, etc.) and focuses on electromechanical energy conversion and the underlying electromagnetic principles.

Description

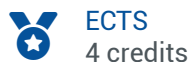
- Explain the physical principles of electromechanical energy conversion.
- Identify and describe the components of electric machines (stator, rotor, windings, magnetic circuits, etc.).
- Distinguish between types of machines based on their operating principles (DC, AC, synchronous, asynchronous).
- Understand the different operating modes of an electric machine.
- Qualitatively analyse the electromagnetic and mechanical behaviour of a machine based on its equivalent circuit.

Pre-requisites

- The fundamentals of electricity and electromagnetism

- The basics of electrical circuit analysis
- Basic mechanical principles

OPTION ENERGY: ELECTROMECHANIC CONVERSION



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** ELP14
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Machine Modeling	UE				
Principles and structures of electrical machines	LV2 facultative				

Machine Modeling



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE08A
- **Open to exchange students:** No

Presentation

Objectives

The course aims to provide machine modeling tools. It also familiarizes students with the structural specificities of rotating machines, such as symmetries, periodicity, the concepts of smooth or salient poles, saturation, and notching effects, all of which are distinguishing features that significantly impact expected performance.

Description

By the end of the course, students will be able to:

- Distinguish between different types of rotating magnetic machines, synchronous or asynchronous machines, smooth poles or salient poles
- Establish basic analytical relationships in order to define a control model
- Deploy the modeling method with the ultimate goal of obtaining a simple steady-state or transient model that can be used, for example, to calculate short-circuit currents or efficiencies.
- Obtain a model for controlling the machine powered by a static converter.
- Calculate steady-state operating points and define the machine's operating ranges in the torque-speed plane.

Principles and structures of electrical machines



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** ELP15
- **Open to exchange students:** No

Presentation

Objectives

Explain the physical principles of electromechanical energy conversion.

- Identify and describe the main structures of electrical machines (stator, rotor, windings, magnetic circuits, etc.).
- Differentiate between types of machines according to their operating principles (DC, AC, synchronous, asynchronous).
- Qualitatively analyze the electromagnetic and mechanical behavior of a machine based on its equivalent circuit.

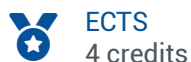
Description

This course presents the operating principles and basic structures of the main electrical machines used in modern industrial electromechanical and energy systems (DC machines, alternators, asynchronous motors, synchronous motors, etc.) and focuses on electromechanical energy conversion, machine modeling, and the underlying electromagnetic principles.

Pre-requisites

- The fundamental concepts of electricity and electromagnetism
- The basics of electrical circuit analysis
- Elementary mechanical principles

SCIENCES HUMAINES SOCIALES ET JURIDIQUES-S7-FISA



ECTS
4 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

> **Ametys Code:** N7AK06

List of courses

	Nature	CM	TD	TP	Crédits
Anglais Professionnel-S7-App	Matière				
Careers and Management 1 - App Sem7	Matière				
Careers and Management 2- APP Sem7	Matière				

Anglais Professionnel-S7-App



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N7AK06A
- **Open to exchange students:** No

Presentation

Objectives

Develop your professional communication skills by performing routine written and oral communication tasks in English.

Description

1 semester of 12 interactive weekly sessions.

Careers and Management 1 - App Sem7



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N7AK06D

Careers and Management 2- APP Sem7



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N7AK06E
- **Open to exchange students:** No

Presentation

Objectives

Develop key professional competencies to communicate effectively, manage projects and work in international teams.

Description

1 semester of 12 weekly sessions aimed to develop your personal professional project.

COMPANY SEMESTER 7



ECTS
10 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N7AE06
- **Open to exchange students:** No

ELECTIVE OPTIONS



ECTS
16 credits



Component
École Nationale
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d'Électronique
d'Informatique
d'Hydraulique
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Télécommunications



Semester
Printemps

In brief

- **Ametys Code:** N8AEAP
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
ENERGY OPTION	UE				16 credits
ELECTRIC SYSTEM	Choix				4 credits
Machine/converter association and their control	UE				
Analysis and modeling of a vehicle through reverse engineering	Stage				
AUTOMATIC AND TR	UE				4 credits
Space State	UE				
sampled linear systems	UE				
Real Time Informatics	UE				
Non Linear Systems	UE				
ECO-ENERGY	UE				4 credits
FACTS Introduction	UE				
Renewable Energies	UE				
POWER ELECTRONICS	UE				4 credits
Inverter	UE				
Switching Mechanisms	UE				
Thermics	UE				
ELECTRONIC OPTION	UE				16 credits
ANALOG CIRCUIT DESIGN	Choix				4 credits
Linear Circuits	UE				
Non Linear Circuits	UE				
Analog Electronics Project	UE				
PROPAGATION AND RADIATION	LV2				4 credits
	facultative				
Transmission Lines	UE				
Electromagnetism and guided propagation	UE				
Radiation and Antennas	UE				
OPTOELECTRONICS AND RADIOFREQUENCIES	UE				4 credits
Optoelectronics	UE				
RF Circuit	UE				
MMIC	UE				
RF-Digital Project	UE				
INTEGRATION	UE				4 credits
MOS	UE				
Front-End instrumentation	UE				
Design and FPGA	UE				

ENERGY OPTION



ECTS

 16 credits



Component

 École Nationale

 Supérieure

 d'Électrotechnique

 d'Électronique

 d'Informatique

 d'Hydraulique

 et des

 Télécommunications

In brief

- > **Ametys Code:** N8AEAB
- > **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
ELECTRIC SYSTEM	Choix				4 credits
Machine/converter association and their control	UE				
Analysis and modeling of a vehicle through reverse engineering	Stage				
AUTOMATIC AND TR	UE				4 credits
Space State	UE				
sampled linear systems	UE				
Real Time Informatics	UE				
Non Linear Systems	UE				
ECO-ENERGY	UE				4 credits
FACTS Introduction	UE				
Renewable Energies	UE				
POWER ELECTRONICS	UE				4 credits
Inverter	UE				
Switching Mechanisms	UE				
Thermics	UE				

ELECTRIC SYSTEM

 **ECTS**
4 credits

 **Component**
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

> **Ametys Code:** ELP11

List of courses

	Nature	CM	TD	TP	Crédits
Machine/converter association and their control	UE				
Analysis and modeling of a vehicle through reverse engineering	Stage				

Machine/converter association and their control



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8AE13C
- **Open to exchange students:** No

Presentation

Objectives

1. Become familiar with the various components of a variable-speed drive for three-phase electric machines.
2. Model electric machines for control purposes.
3. Implement vector control for three-phase electric machines.
4. Derive scalar control algorithms for synchronous and asynchronous machines.
5. Introduction to issues related to high-speed operation.

Description

This course enables students to apply the skills they have acquired in control theory and the modeling of electric machines to design speed controllers for electric machines powered by inverters.

To achieve this objective, the first chapter introduces the principles of controlling a DC machine, which forms the basis for controlling three-phase electric machines. A review of the various models of synchronous and asynchronous machines is provided, specifying the limitations of their use for the synthesis of control laws.

Next, using the Park transform, models dedicated to the control of synchronous and asynchronous machines are presented, detailing the specific characteristics of each type of machine. These models serve as the basis for control design in variable-speed drives for the various machines. Methods for synthesizing control loops (electromagnetic torque, speed, position) are presented, discussing

the limitations imposed by the machine (current limitation) and by the inverter (voltage limitation). Pulse width modulation (PWM) methods for controlling the inverter using continuous controllers are also presented.

Finally, the possibility of reaching different operating points in the torque-speed plane is discussed, with a detailed explanation of the strategies for calculating setpoints for both types of machines. Specific issues related to high-speed control are introduced.

Pre-requisites

N6AE04D - Introduction to Electromechanical Conversion

N7AE08A - Machine Models

N7AE03C - Closed-Loop Control of Continuous Linear Systems

Analysis and modeling of a vehicle through reverse engineering



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** ELP12
- **Open to exchange students:** No

Presentation

Objectives

This project aims to guide students in understanding, modeling, and analyzing the powertrain of an existing electric vehicle using a reverse engineering approach.

Upon completion of the project, students will be able to:

Analyze a complex system (electric vehicle) by identifying its subsystems and their interactions.

Decompose and model the powertrain: battery, drive unit, motor, transmission, and axles.

Develop a comprehensive energy model of the vehicle (power balance, efficiency, estimated range).

Use modeling and simulation tools (e.g., MATLAB/Simulink, Scilab/Xcos, or other equivalent software).

Implement an experimental and validation approach: compare the model with real-world measurements.

Work collaboratively on a multidisciplinary technical project, documenting each step (analysis, modeling, validation, synthesis).

Description

The GOUPIL is a small electric utility vehicle used for industrial, municipal, and logistics applications. Its mechanical simplicity and 100% electric powertrain make it an excellent teaching tool for studying electromechanical and energy systems.

Students will begin their analysis by studying the vehicle and acquiring data from the OBD (on-board diagnostics) system.

They will then be tasked with modeling all the components of the powertrain, dividing the work into subgroups. They will thus need to apply their communication and organizational skills to compare their model with the existing vehicle, analyze the model, and propose potential improvements.

Pre-requisites

- Principles of static converter control
- Principles and models of electrical machines
- Machine/converter association

AUTOMATIC AND TR



ECTS
4 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8AE14
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Space State	UE				
sampled linear systems	UE				
Real Time Informatics	UE				
Non Linear Systems	UE				

Space State



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8AE14A
- **Open to exchange students:** No

Presentation

Objectives

- 1) Model continuous-time and discrete-time dynamic systems in state space,
- 2) Analyze the dynamic behavior of these systems based on their modeling in state space (poles, zeros, stability, controllability, observability, transfer functions, time response),
- 3) Synthesize state-feedback control architectures, and state-feedback with integral action in continuous time,
- 4) Synthesize integer-order and reduced-order observers,

Description

Using control architectures based on low-order linear controllers of type P, PI, or PID allows for the control of a certain class of systems with very good performance, but how can this be done if the open-loop system is already of order 4, 5, ..., 10, ..., 100, ..., as is the case for a large majority of the systems around us and in industry (electrical systems such as converters, electric actuators, or networks); but also renewable energy production systems, vehicles, robots, production lines, heating systems, economic systems, etc. The controllers mentioned earlier are effective over a specific frequency range but have limited effectiveness when it comes to

controlling the dynamic behavior of a high-order system, especially when its poles are spread across the frequency spectrum. This course introduces a modeling formalism called "state-space" modeling, which allows for the analysis and synthesis of appropriate control laws for such systems, regardless of their order, which we encounter daily.

Pre-requisites

Synthesis of controllers and control architectures

Sampled systems

Algebra and matrix operations (matrix multiplication, eigenvalues and eigenvectors, determinant, matrix inversion, diagonalization)

Laplace transform, Integral calculus

sampled linear systems



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
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et des
Télécommunications



Semester

Printemps

In brief

➤ **Ametys Code:** N8AE05B

➤ **Open to exchange students:** No

Presentation

Objectives

Be able to...• Identify the different components and the role of the sampling period,• Construct the equivalent continuous block diagram of a discrete control system,• Calculate the parameters of a continuous controller and discretize it,• Define the block diagram in z,• Calculate the transfer functions in z and the associated time responses,• Calculate the poles and deduce the type of associated time response,• Calculate a PID controller in z and deduce its recursive equation, and vice versa.

Description

Presentation of a sampled speed control: block diagram, functions implemented in a digital controller. Influence of the sampling period: influence of the sampling period on stability, destabilizing effect of Sampling/Hold. Study of control by approximation to a continuous system: definition of the equivalent continuous system, methods for studying sampled controls, synthesis of P controller, discretization of continuous controller. Z-transform: definition and properties, discrete transfer functions, real poles - complex poles. Time-domain study of sampled control systems: static study: accuracy, dynamic study: stability, time responses.

Synthesis of sampled controllers, Experimental tuning of sampled controllers

Criteria for choosing the sampling period: Shannon criterion, real poles, complex poles, phase shift due to sampling/blocking, processing time on the computer, problem of derivation, influence of noise, number coding on microprocessor.

Pre-requisites

- Decomposition into Fourier series,
- Plotting Bode, Black, and Nyquist diagrams, calculations of continuous linear controllers, nested loops, and feedforward chains,
- Basic calculations with the Z-transform, signal transform, inverse transform, final value theorem, initial value theorem, delay...
- Calculations with complex numbers, solving first- and second-order differential equations.

Real Time Informatics



Component

École Nationale
Supérieure
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d'Électronique
d'Informatique
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Télécommunications



Semester

Printemps

In brief

➤ **Ametys Code:** N8AE08A

➤ **Open to exchange students:** No

Presentation

Objectives

The objective of this course is to introduce the basic concepts, organization, and fundamental services of an operating system. The focus is on describing the core services of an operating system kernel in order to discover and practice reactive and parallel multitasking programming within a real-time operating system used in the automotive industry.

Description

This course offers a description of the organization of an operating system, the concept of processes/tasks, task scheduling with a focus on real-time task execution, and multithreaded programming with data sharing and synchronization via monitors. The course includes examples and practical application of these concepts on Unix-Linux and OSEK-TrampolineOS within a design office environment.

Three design offices offer students the opportunity to discover (1) the Unix/Linux shell and basic commands, (3) the implementation of multithreaded applications using monitor-based synchronization mechanisms, and the programming of a real-time application to control an inverted pendulum on a Lego Mindstorms robot using OSEK-TrampolineOS.

Pre-requisites

A solid understanding of algorithms and C programming is essential.

Non Linear Systems



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Printemps

In brief

➤ **Ametys Code:** N8AE05C

➤ **Open to exchange students:** No

Presentation

Objectives

Master the approaches to modeling and analyzing nonlinear dynamic systems

Description

- Review of linear systems and the state equation formalism, definition of a nonlinear system, specific nonlinearities and combination of nonlinearities
- Methods for solving nonlinear systems: linearization around an operating point, first harmonic method, phase plane method
- Illustrative examples: position control with a nonlinearity, predator-prey model, simple pendulum (with and without friction), level regulation

Pre-requisites

modeling and analysis of linear systems

ECO-ENERGY

 **ECTS**
4 credits

 **Component**
École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8AE15
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
FACTS Introduction	UE				
Renewable Energies	UE				

FACTS Introduction



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8AE15A
- **Open to exchange students:** No

Presentation

Objectives

Understand the principles of reactive power control in electric power transmission networks

Description

This course is an introduction to power electronic devices for controlling reactive power in electric power transmission networks. The principles of parallel and series compensation are covered. The method for sizing a compensator based on thyristor-controlled reactors is presented. An example is treated in the form of a case study.

Learn how to size a reactive power compensation device for an electric power transmission line.

Pre-requisites

Methods for modeling and analyzing three-phase electrical networks.

Renewable Energies



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8AE15B
- **Open to exchange students:** No

Presentation

Objectives

- Discover the two renewable electricity generation technologies, photovoltaic and wind. Learn to size various photovoltaic plants (self-consumption, carport, ground-mounted plants). Equipment selection. Cost evaluation, profitability, IRR.
- Introduce the first elements of wind turbine chain design based on their size and technology

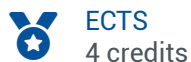
Description

- This course presents the techno-economic aspects of photovoltaics and wind energy.
- Photovoltaics: from the photovoltaic cell to the system, solar radiation, photovoltaic conversion, photovoltaic panels, power plants, cost, environmental impact.
- Wind energy: Characterization of the wind resource, altitude and wake effects, theoretical elements (Betz limit) on wind power output and the energy efficiency of wind turbines; from mechanical control through blade adjustment to operating zones from start-up to safe shutdown.
- Construction of electrical wind turbines: nacelles with and without gearboxes.

Pre-requisites

None

POWER ELECTRONICS



In brief

- **Ametys Code:** N8AE16
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Inverter	UE				
Switching Mechanisms	UE				
Thermics	UE				

Inverter



Component

École Nationale
Supérieure
d'Électrotechnique
d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8AE16A
- **Open to exchange students:** No

Presentation

Objectives

Understand the principles of modulation and filtering of single-phase or three-phase PWM voltage inverters.

Description

This course first presents the basic principles of pulse-width modulation control for single-phase or three-phase voltage inverters. The different waveform forms are analyzed to determine the filtering components for voltages and currents. Examples are addressed in the form of a design office and a project.

Be able to size the filtering components associated with a single-phase or three-phase voltage inverter controlled by pulse-width modulation.

Pre-requisites

Knowledge of the basic structures of static electric power conversion- Knowledge of second-order filters- Basic knowledge of spectral analysis.

Switching Mechanisms



Component

École Nationale
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8AE16B
- **Open to exchange students:** No

Presentation

Objectives

Master the concepts related to the switching of power components used in switched-mode power supplies

Description

This training consists of 3 distinct parts: 1- Introduction to silicon and wide-bandgap (GaN and SiC) power transistors. 2- Analysis of switching and control of generated disturbances (overvoltages, overcurrents, cross-conduction, common-mode currents), 3- Practical implementation of isolations and adjustment of parameters.

Pre-requisites

Basic knowledge of MOSFET transistors

Thermics



Component

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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8AE16C
- **Open to exchange students:** No

Presentation

Objectives

- * Master the analysis of thermal phenomena in power electronics components.
- * Evaluate conduction and switching losses to establish a complete thermal balance.
- * Model thermal systems using equivalent RC networks and utilize manufacturer curves.
- * Understand the impact of temperature on the reliability, voltage withstand, and lifespan of power components.

Description

This module covers the thermal aspects essential to the design and reliability of power electronics devices used in high-power converters, inverters, and power supplies.

The course focuses on heat generation mechanisms, thermal modeling (RC networks, interface resistances), and the analysis tools offered by manufacturers.

It also addresses the selection of cooling solutions and their integration into an architecture, paying particular attention to performance, compactness, and lifespan constraints.

Pre-requisites

Power electronics: operation of power switches, converter topologies.

ELECTRONIC OPTION



ECTS

 16 credits



Component

 École Nationale

 Supérieure

 d'Électrotechnique

 d'Électronique

 d'Informatique

 d'Hydraulique

 et des

 Télécommunications



Semester

 Printemps

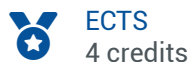
In brief

- > **Ametys Code:** N8AEEA
- > **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
ANALOG CIRCUIT DESIGN	Choix				4 credits
Linear Circuits	UE				
Non Linear Circuits	UE				
Analog Electronics Project	UE				
PROPAGATION AND RADIATION	LV2				4 credits
	facultative				
Transmission Lines	UE				
Electromagnetism and guided propagation	UE				
Radiation and Antennas	UE				
OPTOELECTRONICS AND RADIOFREQUENCIES	UE				4 credits
Optoelectronics	UE				
RF Circuit	UE				
MMIC	UE				
RF-Digital Project	UE				
INTEGRATION	UE				4 credits
MOS	UE				
Front-End instrumentation	UE				
Design and FPGA	UE				

ANALOG CIRCUIT DESIGN



In brief

- **Ametys Code:** ELP10
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Linear Circuits	UE				
Non Linear Circuits	UE				
Analog Electronics Project	UE				

Linear Circuits



Component

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d'Informatique
d'Hydraulique
et des
Télécommunications



Semester

Printemps

In brief

➤ **Ametys Code:** N8AE01A

➤ **Open to exchange students:** No

Presentation

Objectives

To master the concepts related to linear analog circuits based on bipolar transistors and MOSFETs.

Description

This course consists of four distinct lessons covering: the cascoded common-emitter configuration, the linear regulator, class A, B, and AB amplifiers, and the silicon MOSFET transistor. Each topic is illustrated with simulations using PSpice, allowing students to grasp the concepts covered in the lectures.

Pre-requisites

Fundamentals of transistor circuits (covered in the third year of undergraduate studies).

Non Linear Circuits



Component

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Semester

Printemps

In brief

- **Ametys Code:** N8AE01B
- **Open to exchange students:** No

Presentation

Objectives

Master the concepts related to nonlinear analog circuits based on bipolar transistors.

Description

These lessons consist of 4 separate courses covering: VCO, PLL, charge transfer devices, TTL and CMOS logic at the transistor level. Each topic is illustrated with simulations in PSpice, allowing the concepts taught in class to be understood.

Pre-requisites

Basic knowledge of transistor circuits

Analog Electronics Project



Component

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Semester

Printemps

In brief

- **Ametys Code:** N8AE01C
- **Open to exchange students:** No

Presentation

Objectives

To design and build an FM receiver capable of receiving an audio signal via an infrared optical wireless link.

- Sizing of analog electronic functions (amplification, demodulation, filtering)
- Simulation and validation of circuits
- Implementation on a printed circuit board (PCB)
- Experimental testing and oral presentation of the final product

Description

The project consists of designing, simulating, building, and testing an analog FM receiver integrating the following functions:

- High-gain selective amplification
- FM demodulation: using a phase-locked loop (PLL)

- Filtering of the audio signal from the demodulator
- Power amplification and speaker connection

Pre-requisites

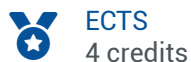
Electrical circuit analysis methods

Signal transistors and operational amplifiers

Transistor amplifier circuits and operational amplifier circuits

Phase-locked loop

PROPAGATION AND RADIATION



In brief

- **Ametys Code:** ELP13
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Transmission Lines	UE				
Electromagnetism and guided propagation	UE				
Radiation and Antennas	UE				

Transmission Lines



Component

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Semester

Printemps

In brief

➤ **Ametys Code:** N8AE03A

➤ **Open to exchange students:** No

Presentation

Objectives

At the end of this course, students will be able to:

- Qualify propagation in transmission lines.
- Analyze reflections when the line is loaded.
- Develop appropriate adaptation techniques based on loads and frequency bands.

Students will be able to qualify these different concepts both analytically and on a Smith chart.

Description

In this course, students will learn about guided propagation (reflection, transmission, standing waves). They will use Smith charts to solve circuits. Matching techniques will be explained in detail (using discrete components, quarter-wave inverters, simple stub

circuits). S parameters will be introduced, as well as the network analyzer used to measure them. Exercises will illustrate the course. An ADS Design Office also allows students to understand and verify the adaptation techniques used.

Pre-requisites

Circuit basics. Mathematics basics (complex calculations, linear algebra, trigonometry)

Electromagnetism and guided propagation



Component

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Télécommunications



Semester

Printemps

In brief

➤ **Ametys Code:** N8AE03B

➤ **Open to exchange students:** No

Presentation

Objectives

Be able to physically analyze the interaction of a plane electromagnetic wave with an interface (dielectric or metallic)

Know the main properties of a plane wave

Understand what a mode in a waveguide refers to

Understand what the cutoff frequency of a mode refers to

Understand what dispersion refers to

Be able to calculate the power carried by a propagating mode in a waveguide

Description

I- Laws of classical electromagnetism

I-1- Concept of instantaneous electromagnetic fields

I-2- Maxwell's equations

I-3- Harmonic regime in electromagnetism

II- Electromagnetic propagation in free space

II-1- Electromagnetic field in free propagation

II-2- Group and phase velocities in free propagation

II-3- Application: interaction of a plane wave with a surface (metallic or dielectric)

III- Guided electromagnetic propagation

III-1- Electromagnetic field in guided propagation

III-2- Concept of propagating and evanescent modes

III-3- Dispersion phenomenon in electromagnetism

III-4- Group and phase velocities in guided propagation

III-5- Application: Calculation of the fundamental mode in a hollow rectangular metallic waveguide

Pre-requisites

Complex numbers - Differentiation and integration of functions of a real variable - Basic concepts of electricity and magnetism - Kirchhoff's laws (node law and loop law) and Ohm's law - Basic knowledge of analog electrical circuits.

Radiation and Antennas



Component

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d'Hydraulique
et des
Télécommunications



Semester

Printemps

In brief

➤ **Ametys Code:** N8AE09A

➤ **Open to exchange students:** No

Presentation

Objectives

The objectives of this course are:

- to understand an antenna datasheet
- to be able to choose the right antenna given a set of specifications
- to know how to qualify an antenna (simulation/measurement)
- to know how to analyze antenna simulation/measurement curves

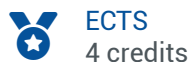
Description

Students will become familiar with the concept of wave propagation and electromagnetic radiation. They will learn about the different characteristics of antennas (datasheet) and the different families of antennas. Antenna networking will be discussed. Antenna simulation and measurement techniques will be detailed.

Pre-requisites

Complex calculus. Basics of electromagnetism.

OPTOELECTRONICS AND RADIOFREQUENCIES



In brief

- **Ametys Code:** N8AE11
- **Open to exchange students:** No

List of courses

	Nature	CM	TD	TP	Crédits
Optoelectronics	UE				
RF Circuit	UE				
MMIC	UE				
RF-Digital Project	UE				

Optoelectronics



Component

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Télécommunications

In brief

- **Ametys Code:** N8AE11A
- **Open to exchange students:** No

Presentation

Objectives

By the end of this course, students will be able to:

- Understand the fundamental principles of optical fiber communications and the physical properties of optical fibers (attenuation, bandwidth).
- Describe the operation and characteristics of light sources (PN junction LEDs, laser diodes) and photodetectors (photodiodes).
- Design and analyze amplification and filtering circuits for optical receivers, considering noise and bandwidth constraints.
- Evaluate the impact of noise in photodetection and propose solutions to optimize signal-to-noise ratio (SNR).
- Apply theoretical knowledge to practical scenarios in fiber optic communication systems.

Description

This course provides an introduction to optoelectronics, focusing on fiber optic communication systems. The main topics covered include:

- **Optical Fiber Fundamentals:** Types of optical fibers, attenuation mechanisms, dispersion, and bandwidth limitations.
- **Light Sources:** Operation and characteristics of PN junction-based light sources (LEDs and laser diodes), including modulation and efficiency.
- **Photodetectors:** Principles of photodiodes (PIN, APD), responsivity, and noise mechanisms.
- **Amplification and Filtering Electronics:** Design of transimpedance amplifiers (TIAs), noise analysis, and filtering techniques for optical receivers.
- **Noise in Photodetection:** Sources of noise (shot noise, thermal noise, dark current), and strategies to minimize their impact on system performance.
- **System-Level Considerations:** Integration of components into fiber optic communication links, including budget calculations and performance optimization.

The course combines theoretical lectures, practical exercises, and laboratory sessions to reinforce concepts and develop hands-on skills.

Pre-requisites

- Basic knowledge of semiconductor physics and PN junctions.
- Familiarity with analog electronics (amplifiers, filters, and noise analysis).
- Understanding of fundamental communication principles (modulation, signal transmission).

RF Circuit



Component

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Télécommunications



Semester

Printemps

In brief

- **Ametys Code:** N8AE03C
- **Open to exchange students:** No

Presentation

Objectives

- Design passive functions using ideal transmission lines
- - Learn to synthesize an RF passive function
- - Size a passive device based on couplers

Description

Course: Study of microwave spectrum and applications: Microwave filters based on transmission lines: Richards transformation, Kuroda transformation, impedance inverter model, concept of periodicity and out-of-band response control Multipoles: Power dividers Couplers: hybrid, magic T, proximity couplers, cascade-Tandem assemblies, Lange coupler Design of coupler-based functions: phase shifter, attenuator, multiplexer, mixer, balanced configuration

- Lab: Non-linear simulation of a frequency conversion chain (ADS). Design of a band-pass filter with stubs: from synthesis to electromagnetic simulation

Pre-requisites

Transmission lines

MMIC



Component

École Nationale
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d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8AE11B
- **Open to exchange students:** No

Presentation

Objectives

Design active functions integrated on-chip

Description

- Course: Study planar microwave technologies: hybrid, monolithic (MMIC) Design of RF amplifiers: Transistor biasing, classes of amplification Linearity concepts: P1dB, IM3, IP3, OBO/IBO, efficiency, PAE Transistor stabilization: Stability circle, stability zone, Rollet coefficients (K, B), stabilization methodology, MSG, MAG Gain-optimized amplifier, Fixed-gain amplifier, Low-noise amplifier MMIC design: from transistor to integrated amplifier and extraction of linearity characteristics

- Project: Design of a GaAs MMIC chip: Using OMMIC-foundry library - ED02AH. Design of a LNA (Low-Noise Amplifier) meeting real space equipment specifications (Thales Alenia Space)

Pre-requisites

Transmission Lines

RF-Digital Project



Component

École Nationale
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d'Électronique
d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8AE11C
- **Open to exchange students:** No

Presentation

Objectives

To design, implement, and validate a mixed analog-digital data transmission system based on a functional specification.

- Apply acquired knowledge in analog and digital electronics and FPGA design.
- Develop autonomy in project management.
- Select the sampling frequency and components to meet the specifications.
- Conduct experimental tests and present the final product orally.

Description

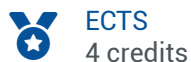
- The analog functions will be implemented using operational amplifier circuits and switching MOSFET transistors, tested through simulation before being implemented on a PCB.

- The digital part will be developed in VHDL on an FPGA development board.
- The choice of sampling frequency and components must be justified.

Pre-requisites

- Operational amplifier circuits
- MOSFET transistors in switching mode
- Transmission gates (MOSFETs)
- Voltage level converters (MOSFETs)
- Digital functions: counters, state machines, etc.
- VHDL programming language

INTEGRATION



In brief

> **Ametys Code:** N8AE12

List of courses

	Nature	CM	TD	TP	Crédits
MOS	UE				
Front-End instrumentation	UE				
Design and FPGA	UE				

MOS



Component

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et des
Télécommunications

In brief

- **Ametys Code:** N8AE12A
- **Open to exchange students:** No

Presentation

Objectives

Understand the basic structures of integrated electronics using MOS transistors
Design amplification chains
Understand the principle of amplifier compensation via the Miller effect
Design an amplifier according to specifications

Description

Through this course, 3 parts are covered:

- (1) the fundamental functions achieved using MOS and bipolar transistors;
- (2) the principle of feedback
- (3) the compensation method based on the Miller effect of an amplifier.
- (4) designing a CMOS amplifier (theory, simulation)

Pre-requisites

Basic circuits

Operational amplifier and compensation

Semiconductor and PN junction physics

Signal transistors and power components

Transistor amplifier circuits

Front-End instrumentation



Component

École Nationale
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d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8AE12B
- **Open to exchange students:** No

Presentation

Objectives

By the end of this course, students will be able to:

- Understand the fundamental principles of analog-to-digital (ADC) and digital-to-analog (DAC) conversions.
- Analyze sources of noise and error in instrumentation chains, including quantization noise and spectral aliasing.
- Design and size appropriate anti-aliasing filters, particularly using switched-capacitor filters.
- Select and configure components (ADCs, DACs, filters) based on application requirements.
- Evaluate the performance of signal acquisition or generation chains.

Description

This course covers the principles and challenges of signal conversion and processing in instrumentation chains. Key topics include:

- Analog-to-Digital (ADC) and Digital-to-Analog (DAC) Conversion: Architectures (flash, SAR, sigma-delta, etc.), resolution, speed, and limitations.
- Noise and Errors: Quantization noise, signal-to-noise ratio (SNR), total harmonic distortion (THD), and spectral aliasing.
- Associated Filtering: Design of anti-aliasing filters, switched-capacitor filters, and digital filters (FIR, IIR).
- Practical Applications: Case studies on acquisition chains (sensors, conditioning, ADC) and signal generation (DAC, reconstruction, filtering).
- Tools and Methods: Use of simulation software (PSpice, MATLAB) and measurement instruments (oscilloscope, spectrum analyzer).

The course combines theoretical lectures, tutorials, and lab sessions to apply concepts to real-world problems.

Pre-requisites

- Basic knowledge of analog electronics (operational amplifiers, passive and active filters).
- Familiarity with signal processing concepts (Fourier transform, sampling).
- Experience with simulation software (PSpice, MATLAB).
- Basic knowledge in FPGA programming (VHDL, Vivado)

Design and FPGA



Component

École Nationale
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d'Informatique
d'Hydraulique
et des
Télécommunications

In brief

- **Ametys Code:** N8AE12C
- **Open to exchange students:** No

Presentation

Objectives

To design, implement, and validate a mixed analog-digital data transmission system based on a functional specification.

- Apply acquired knowledge in analog and digital electronics and FPGA design.
- Develop autonomy in project management.
- Select the sampling frequency and components to meet the specifications.
- Conduct experimental tests and present the final product orally.

Description

- The analog functions will be implemented using operational amplifier circuits and switching MOSFET transistors, tested through simulation before being implemented on a PCB.
- The digital part will be developed in VHDL on an FPGA development board.

- The choice of sampling frequency and components must be justified.

Pre-requisites

- Operational amplifier circuits
- MOSFET transistors in switching mode
- Transmission gates (MOSFETs)
- Voltage level converters (MOSFETs)
- Digital functions: counters, state machines, etc.
- VHDL programming language

SCIENCES HUMAINES SOCIALES ET JURIDIQUES-S8-FISA



ECTS
4 credits



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

> **Ametys Code:** N8AK06

List of courses

	Nature	CM	TD	TP	Crédits
Anglais Professionnel-S8-App	Matière				
Careers and Management 1	Matière				
Careers and Management 2	Matière				

Anglais Professionnel-S8-App



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

- **Ametys Code:** N8AK06A
- **Open to exchange students:** No

Presentation

Objectives

Develop your professional communication skills by performing routine written and oral communication tasks in English.

Description

1 semester of 12 interactive weekly sessions.

Careers and Management 1



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M4RA3IUS

Careers and Management 2



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** M4RA3J05

COMPANY SEMESTER 8



ECTS
10 credits



Component
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Semester
Printemps

In brief

- **Ametys Code:** N8AE06
- **Open to exchange students:** No

OUTILS NUMERIQUES POUR LA PROPAGATION



ECTS
5 credits

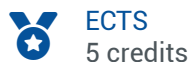


Component
École Nationale
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In brief

> **Ametys Code:** N9EE01

PHYSIQUE ET OPTIMISATION



In brief

➤ **Ametys Code:** N9EE02

List of courses

	Nature	CM	TD	TP	Crédits
Physique et modélisation	Matière				

Physique et modélisation

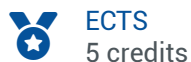


Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

> **Ametys Code:** N9EE02A

METHODES NUMERIQUES



In brief

> **Ametys Code:** N9EE03

List of courses

	Nature	CM	TD	TP	Crédits
Projet Méthode numérique et calcul haute performance	Matière				

Projet Méthode numérique et calcul haute performance



Component
École Nationale
Supérieure
d'Électrotechnique
d'Électronique

In brief

➤ **Ametys Code:** N9EE03B