



People's Democratic Republic of Algeria  
République Algérienne  
Démocratique et Populaire  
Ministry of Higher Education and Scientific Research  
Ministry of Higher Education and Scientific Research  
National Pedagogical Committee for Science and Technology  
National Pedagogical Committee of the Science and Technology field



# **ACADEMIC MASTER'S DEGREE** **HARMONISE**

## **National Program**

### **UPDATE 2025**

Domain	Stream	Specialty:
<i>Sciences and Technologies</i>	<i>Electronics</i>	<i>Instrumentation</i>



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# **Master Academy Harmonization National Program Update 2025**

<b>Specialization</b>	<b>Branch</b>	<b>The square</b>
<b>Instruments</b>	<b>Electronics</b>	<b>Science &amp; Technology</b>

**I – Master's identity sheet**

### Conditions of access

*(Indicate the bachelor's specialties that can give access to the Master's degree)*

Stream	Harmonized Master's Degree	Access Licenses Master's degree	Classification according to license compatibility	Coefficient assigned to the licence
<b>Electronics</b>	Instrumentation	Electronics	<b>1</b>	<b>1.00</b>
		Telecommunications	<b>2</b>	<b>0.80</b>
		Biomedical Engineering	<b>2</b>	<b>0.80</b>
		Automatic	<b>3</b>	<b>0.70</b>
		Electrical engineering	<b>3</b>	<b>0.70</b>
		Electromechanics	<b>4</b>	<b>0.65</b>
		Other ST Domain Licenses	<b>5</b>	<b>0.60</b>

**II - Semester organisation sheets for teaching  
of the specialty**

**Semester 1**

Teaching unit	Materials	Credits	Coefficient	Weekly hourly volume			Semi-Annual Hourly Volume (15 weeks)	Complementary work in Consultation (15 weeks)	Evaluation method	
	Title			Courses	TD	TP			Continuous assessment	Review
Core UE Code: UEF 1.1.1 Credits: 10 Coefficients : 5	Instrumentation electronics	6	3	3:00 pm	1h30		67h30	82:30 p.m.	40%	60%
	Industrial Instrumentation Sensors	4	2	1h30	1h30		45h00	55:00 pm	40%	60%
Core UE Code: UEF 1.1.2 Credits: 8 Coefficients : 4	Advanced Signal Processing 01	4	2	1h30	1h30		45h00	55:00 pm	40%	60%
	Industrial Metrology	4	2	1h30	1h30		45h00	55:00 pm	40%	60%
Methodological UE Code: EMU 1.1 Credits: 11 Coefficients : 7	Practical Instrumentation Electronics	2	1			1h30	10:30 p.m.	27:30	100%	
	TP Sensors in industrial instrumentation	2	1			1h30	10:30 p.m.	27:30	100%	
	Advanced Signal Processing 01/Industrial Metrology TP	2	1			1h30	10:30 p.m.	27:30	100%	
	Industrial Actuators	3	2	1h30		1h30	45h00	30:00 pm	40%	60%
	Advanced programming in Python	2	2	1h30		1h30	45h00	5:00 pm	40%	60%
Discovery UE Code: UED 1.1 Credits: 1 Coefficients : 1	Choice of material	1	1	1h30			10:30 p.m.	02:30 am		100%
<b>Total semester 1</b>		<b>30</b>	<b>17</b>	<b>12:00 p.m.</b>	<b>6:00 pm</b>	<b>7:30 a.m.</b>	<b>382h30</b>	<b>367h30</b>		

**Semester 2**

Teaching unit	Materials	Credits	Coefficient	Weekly hourly volume			Semi-Annual Hourly Volume (15 weeks)	Complementary work in Consultation (15 weeks)	Evaluation method	
	Title			Courses	TD	TP			Continuous assessment	Review
Core UE Code: UEF 1.2.1 Credits: 10 Coefficients : 5	Microcontrollers and DSPs	6	3	3:00 pm	1h30		67h30	82:30 p.m.	40%	60%
	Digital Servo Systems	4	2	1h30	1h30		45h00	55:00 pm	40%	60%
Core UE Code: UEF 1.2.2 Credits: 8 Coefficients : 4	Advanced Digital Electronics: VHDL - FPGA	4	2	1h30	1h30		45h00	55:00 pm	40%	60%
	Advanced Signal Processing 02	4	2	1h30	1h30		45h00	55:00 pm	40%	60%
Methodological UE Code: EMU 1.2 Credits: 9 Coefficients : 5	Microcontrollers and DSP TP	2	1			1h30	10:30 p.m.	27:30	100%	
	TP Digital Servo Systems/ TP Advanced Signal Processing 02	2	1			1h30	10:30 p.m.	27:30	100%	
	TP VHDL - FPGA	2	1			1h30	10:30 p.m.	27:30	100%	
	Project-based learning	3	2	1h30		1h30	45h00	30:00 pm	40%	60%
Transversal UE Code: UET 1.2 Credits: 3 Coefficients : 3	Elements of Applied AI	2	2	1h30	1h30		45h00	5:00 pm	40%	60%
	Compliance with the standards and rules of ethics and integrity	1	1	1h30			10:30 p.m.	02:30 am		100%
<b>Total semester 2</b>		<b>30</b>	<b>17</b>	<b>12:00 p.m.</b>	<b>6:00 pm</b>	<b>7:30 a.m.</b>	<b>382h30</b>	<b>367h30</b>		

**Semester 3**

Teaching unit	Materials	Credits	Coefficient	Weekly hourly volume			Semi-Annual Hourly Volume (15 weeks)	Complementary work in Consultation (15 weeks)	Evaluation method	
	Title			Courses	TD	TP			Continuous assessment	Review
Core UE Code: UEF 2.1.1 Credits: 10 Coefficients : 5	Programmable logic controllers	4	2	1h30	1h30		45h00	55:00 pm	40%	60%
	Industrial Actuators	4	2	1h30	1h30		45h00	55:00 pm	40%	60%
	Advanced sensors and measurement systems	2	1	1h30			10:30 p.m.	27:30		100%
Core UE Code: UEF 2.1.2 Credits: 8 Coefficients : 4	Advanced Power Electronics	4	2	1h30	1h30		45h00	55:00 pm	40%	60%
	Digital control elements	4	2	1h30	1h30		45h00	55:00 pm	40%	60%
Methodological UE Code: EMU 2.1 Credits: 9 Coefficients : 5	TP Programmable Logic Controllers	2	1			1h30	10:30 p.m.	27:30	100%	
	TP Industrial Actuators/TP Digital Control	2	1			1h30	10:30 p.m.	27:30	100%	
	Advanced Power Electronics TP	2	1			1h30	10:30 p.m.	27:30	100%	
	Reliability and maintenance of electronic systems	3	2	1h30		1h30	45h00	30:00 pm	40%	60%
Transversal UE Code: UET2.1 Credits: 3 Coefficients : 3	Reserve engineering	2	2	1h30	1h30 Workshop		45h00	5:00 pm	40%	60%
	Literature search and memory design	1	1	1h30			10:30 p.m.	02:30 am		100%
Total semester 3		30	18	12:00 p.m.	6:00 pm	7:30 a.m.	382h30	367h30		

### General guidelines on the choice of discovery subjects:

The subjects discovered in the Master of Instrumentation Subject Repository (Table above) are left to the free choice of the institutions, which can choose their subjects from the list presented below according to their priorities.

#### Subjects with detailed programmes:

- Optoelectronics
- Autonomous energy systems
- Electroacoustics and vibration analyses
- Electromagnetic compatibility
- Industrial Instrumentation & Measurement
- Industrial safety
- Robotics
- Adjustment of Electric Drives
- Bio instrumentation and biosensors
- Methods and tools for non-destructive testing
- Tools for Instrumentation Maintenance
- Industrial maintenance and diagnostics
- Industrial Networks & Communication

#### Other subjects left to the free choice of the institutions (programs open after validation of the CPND)

- Display Systems(Discovery)
- Measuring Instruments(Discovery)
- High-Frequency Measurements(Discovery)
- Electroacoustics, Sound and HIFI(Discovery)
- Industrial Remote Management (SCADA) (Discovery)
- Industrial Systems Control Theory (Discovery)
- Smart Sensors in Industrial Instrumentation(Discovery)
- Operations Research

### Semester 4

Internship in a company or in a research laboratory sanctioned by a dissertation and a defense.

	VHS	Coeff	Credits
Personal work	550	09	18
Internship in a company or laboratory	100	04	06
Seminars	50	02	03
Other (Framing)	50	02	03
Total Semester 4	750	17	30

**This table is given for information purposes only**

### Evaluation of the Master's End of Cycle Project

- |  |    |    |
|--|----|----|
| - Scientific value (Jury's assessment)                     | /6 |    |
| - Writing of the Thesis (Jury's Assessment)                | /4 |    |
| - Presentation and answer to questions (Jury's assessment) |    | /4 |
| - Supervisor's assessment                                  | /3 |    |
| - Presentation   |    | /3 |

**III - Detailed programme by subject of the S1 semester**

**Semester: 1**  
**Teaching unit: UEF 1.1.1**  
**Material 1: Instrumentation Electronics**  
**VHS: 67h30 (Lecture: 3h00, TD: 1h30)**  
**Credits: 6**  
**Coefficient: 3**

**Teaching objectives:**

Study and analysis of analog electronic circuits used in measurement and instrumentation chains.

**Recommended prior knowledge:**

Fundamental Electronics 1 and 2, Functions of Electronics, Pulse Electronics.

**Material content:**

**Chapter 1. The operational amplifier and AOp-based assemblies (02 weeks)**

- 1.1. Operating Amplifier (AOp) Modes of Operation
- 1.2. Operation of an AOp in linear mode (Inverting amplifier, Non-inverting amplifier, Voltage follower, Differential amplifier, Adding or summing amplifier, Integrator, Derivator, Logarithmic and exponential setups)
- 1.3. Operation of an AOp in nonlinear mode (comparator, AOp in saturation regime)
  - 1.3.1. Simple Comparator (Single-Threshold Comparator)
    - Simple to zero comparator
    - Single non-inverting comparator
  - 1.3.2. Two-threshold comparator
    - Non-inverting Schmitt Trigger Comparator
    - Comparator Schmitt Trigger inverter
  - 1.3.3. Window Comparator
    - Window Comparator-1
    - Window Comparator-2
- 1.4. The use of the PDO according to its characteristics (accuracy, noise, gain-frequency product, etc.), 1.5. The instrumentation amp.
- 1.6. Comparison.

**Chapter 2. A-D and D-A signal converters (03 weeks)**

- 2.1. Introduction (Role, Digital Process Processing Chain, Signal Classification)
- 2.2. Analog-to-Digital Conversion (ADC)
  - 2.2.1. Sample-Blocker (Sample and Hold)
  - 2.2.2. Converter Characteristics (ADC Resolution, Full Scale or Conversion Range, Transfer Characteristic, Conversion Time  $T_c$ , Offset Error (Offset Error), Gain Error, Linearity Error, Quantization Error)
  - 2.2.3. Architecture of Analog-to-Digital Converters
    - Integration converters (single ramp ADC (pulse-counting), dual-ramp ADC (pulse-counting))
    - Successive approximation or successive weighing converter (SAR Converter)
    - Flash converter (parallel or direct comparison converter)
  - 2.2.4. Comparison between NACs
  - 2.2.5. A/D converter based on a D/A converter
- 2.3. Digital to Analog Converter DAC (DAC)
  - 2.3.1. Characteristics of N-A converters (Resolution of a DAC and conversion range, Transfer characteristic)
  - 2.3.2. Digital-to-Analog Converter Architectures

- Weighted resistor array (or current-weighted) digital-to-analog converters
  - R-2R Resistor Array Digital-to-Analog Converters
- 2.3.3. Comparison between the NAC

### **Chapter 3. Pulse or signal generation circuits (04 weeks)**

- 3.1. Reminder on the charging and discharging of a capacitor and the switched transistor
- 3.1.1. Charging and discharging a capacitor (Preliminary notions, Electrical model of a capacitor C, charging a capacitor through a resistor (by a voltage step), discharging a capacitor through a resistor R)
- 3.1.2. Switching transistor
- 3.2. Linear and nonlinear oscillators
- 3.2.1. Linear Oscillators
- Damped harmonic oscillators,
  - Harmonic Oscillators (Negative Resistance Oscillator )
- 3.2.2. Nonlinear Oscillators
- Van der Pol Oscillator (Differential Equation, Experimental Study, Computer-Aided Theoretical Approach)
- 3.3. Voltage-Controlled Oscillator (VCO)
- 3.4. Phase Locked Loop
- The components of the PLL (Phase Comparator (Phase Error Detector), Low-Pass Filter, Voltage-Controlled Oscillator (VCO)
  - Principle of operation of the PLL)
- 3.5. Asstable and Monostable (multivibrators).
- 3.5.1. Asstable (Transistor, Op-Amp, NE555, Logic Gate)
- 3.5.2. Monostable (Transistor, Op-Amp, NE555, Logic Gate)

### **Chapter 4. Signal Processing Circuits**

**(03 weeks)**

- 4.1. But de la modulation
- 4.2. Structure of a telecommunications system
- 4.3. Amplitude Modulation (AM), synchronous detection
- 4.3.1. Dual sideband amplitude modulation with carrier
- 4.3.2. Suppressed Dual Carrier Sideband Amplitude Modulation
- 4.3.3. Single Side Band (SSB) amplitude modulation
- 4.3.4. Quadrature Amplitude Modulation (QAM)
- 4.3.5. Synchronous or coherent demodulation (AM signal demodulation with carrier, AM signal demodulation with carrier removed, Demodulation of a single sideband AM signal, Demodulation of a QAM signal)
- 4.4. Frequency Modulation (FM), synchronous detection
- 4.4.1. General information on FM modulation (Expression of a frequency-modulated wave, Spectrum of an FM signal, Frequency band, Power in FM signals; Performance)
- 4.4.2. Frequency Modulators (Varicap Diode Modulation, Armstrong Modulator)
- 4.4.3. Synchronous Demodulation of FM Signals (Phase-Locked Loop Demodulation)
- 4.5. Modulation de phase (PM : Phase Modulation)
- 4.6. Pulse Modulation
- 4.6.1. Analog Pulse Modulation
- Pulse-to-amplitude modulation (PMA)
  - Pulse-in-Time Modulation (PIM)
  - Pulse-in-position modulation (PIM)
- 4.6.2. Digital (digital) pulsed modulation
- Pulse Code Modulation (PCM)

### **Chapter 5. Study of active filters**

**(03 weeks)**

- 5.1. Interest of active filters

- 5.2. General Characteristics (Filtering, Transfer Function, Bode Diagram, Normalized Variables, Passive Filter and Active Filter, Main Jigs)
- 5.3. Filter approximation functions
  - 5.3.1. Quadratic Filters (Biquadratic Functions)
  - 5.3.2. Bode Diagram of the 2nd Order Low-Pass Filter
  - 5.3.3. Butterworth Filters (Low-Pass Filter)
  - 5.3.4. Bessel Filters
  - 5.3.5. Chebyshev Filters (Low-Pass Filter)
- 5.4. Frequency transposition (transformation, variable change)
- 5.5. Synthesis of active filters
  - 5.5.1. Synthesis phases
  - 5.5.2. First-order filter (First-order low-pass filter (or 20 dB/dec = 6 dB/octave filter), First-order high-pass filter (or 20 dB/dec = 6 dB/octave filter))
  - 5.5.3. Second Order Filter (Sallen Key and Rauch Filters, 2nd Order Low Pass Filter (or -40 dB/decade filter), 2nd Order High Pass Filter (or 40 dB/decade filter), 2nd Order Bandpass Filter)

**Method of evaluation:**

Continuous assessment: 40%; Examination: 60%.

**Bibliographical references:**

- [1] . A. Damaye, *Les Oscillateurs, Generators et synthesiseurs de signals (2nd revised and expanded edition)*, Distribution: Editions Techniques et Scientifiques Françaises, Paris Cedex 19.
- [2] . A.P. Malvino, *Principles of Electronics, 6th edition; Sciences-Sup, Dunod.*
- [3] . J. Millman, *Microelectronics, Ediscience.*
- [4] . J. Encinas, *Phase Locking System (P.L.L): achievements and applications.*
- [5] . H.H. Ouslimani, A. Ouslimani, *Fonctions principales d'électronique : Cours et exercices résolus, Editions CASTEILLA, 2010.*
- [6] . F. Milsant, *Cours d'électronique tome 4 ; Eyrolles, 1994.*
- [7] . G. Metzger, J.P. Vabre, *Electronique des impulsions, Volume 1, 3rd edition; Masson, 1985.*
- [8] . J-D. Chatelain and R. Dessoulavy, *Electronics, Volumes 1 and 2; Dunod.*
- [9] . S. Boubeker, *Electronique des impulsions, OPU, 1999.*
- [10] . B. Haraoubia, *Les amplificateurs opérationnelle (Operational amplifiers), Functioning and applications, ENAG Editions, 1994.*

**Semester:1**  
**Teaching unit: UEF 1.1.1**  
**Subject2: Industrial Instrumentation Sensors**  
**VHS: 45h00 (Lecture: 1h30, TD: 1h30)**  
**Credits: 4**  
**Coefficient: 2**

**Teaching objectives:**

Acquire extensive technological knowledge of the various sensors encountered in an industrial environment and their uses (metrology, data acquisition). Understand a specification sheet for any type of sensor.

**Recommended prior knowledge:**

Analog Electronics, Electronics Functions, Electrical and Electronic Measurements, Signal Processing.

**Material content:**

**Chapter 1: Concepts about Sensors (02 weeks)**

Measurable quantities, Vocabulary, Roles of a sensor, Types of measurands, General characteristics of a sensor: measurement range, sensitivity, reproducibility, Linear operation, hysteresis, resolution, drift, measurement errors,... Parasites. Type of sensors (active, passive, composite, etc.), simple, integrated and/or intelligent sensors.

**Chapter 2: Sensor Conditioning (04 weeks)**

Definition of a conditioning circuit, Potentiometric assembly (Measurement of resistances, Measurement of complex impedances, The disadvantages of potentiometric assembly. Wheatstone Bridge, Complex Impedance Measurements, Kelvin, Wien, Maxwell, Owen, Hay, Anderson, ..., Instrumentation Amplifiers, Differential Amplifiers, Charge Amplifiers and Isolation Amplifiers. Linearization and nonlinear conditioning circuits. Evaluation of the distortion of packaging systems. Packaging and EMC.

**Chapter 3: Examples of Industrial Sensors (04 weeks)**

Position and displacement sensor. Pressure Sensor. Level sensor. Temperature sensor (thermocouple and Pt100 ...). Flow sensor. Current sensor, strain gauges,...

**Chapter 4: Sensor Transmission Systems (03 weeks)**

Transmitters (Interest of a transmitter, Parameterization of transmitters, choice of a transmitter, 4-20mA current loop, Symbols, intelligent transmitters). Analog and digital transmission systems. Voltage and current transmission (4-20 mA). Modulation/demodulation techniques. Synchronous or asynchronous serial digital transmission. Principles, characteristics and protocols (RS232C, RS422, RS485, ...).

**Chapter 5: Introduction to Smart Sensors (02 weeks)**

Advantages and principles, general architecture (capture module, processing unit, communication interface, power module), advantages and disadvantages, Smart sensor networks, examples of communication protocols.

**Chapter 1: Sensor Reminders (01weeks)**

Passive and Active Sensors, Measurable Quantities, Sensor Classifications

**Chapter 2: Smart Sensors (06 weeks)**

Definitions. Static and dynamic properties. Internal structure of a smart sensor: Packaging circuits, Data processor, Communication interface. Metrology of smart sensors: Calibration, Accuracy and validation of measurements, Remote commissioning, Self-diagnosis. Sensor networks

**Evaluation method:**

Continuous assessment: 40%; Examination: 60%.

**Bibliographical references**

- [1] . *Georges Asch and Collaborators. Sensors in industrial instrumentation, Dunod 2006*
- [2] . *Ian R. Sinclair. Sensors and transducers, Newnes, 2001.*
- [3] . *J. G. Webster. Measurement, Instrumentation and Sensors Handbook, Taylor & Francis Ltd.*
- [4] . *M. Grout. Industrial Instrumentation: Specification and Installation of Sensors and Control Valves, Dunod, 2002.*
- [5] . *R. Palas-Areny, J. G. Webster. Sensors and signal conditioning, Wiley and Sons, 1991.*
- [6] . *R. Sinclair, Sensors and Transducers, Newness, Oxford, 2001.*
- [7] . *M. Cerr, Industrial Instrumentation: T.1 and T.2, Edition Tec and Doc.*
- [8] . *N. Ichinose, Practical Guide to Sensors, Masson*
- [9] . *P. Dassonville, Les capteurs, Dunod 2013.*

**Semester: 1**  
**Teaching unit: UEF 1.1.2**  
**Topic 3:Advanced Signal Processing 1**  
**VHS: 45h00 (Lecture: 1h30, TD: 1h30)**  
**Credits: 4**  
**Coefficient: 2**

**Teaching objectives:**

This course is designed to enable students to:

- ✓ Master and apply digital filtering methods
- ✓ Evaluating the performance of a digital filter
- ✓ Understand the transition from the analog to the digital domain.

**Recommended prior knowledge:**

The student will have the following knowledge:

- ✓ The mathematical basics;
- ✓ Discrete Fourier Transform (DFT)
- ✓ Analog filtering (analysis and syntheses);

**Material content:**

**Chapter 1. Reminders about analog filters**

**(3 weeks)**

- Filter Features
- Different types of analog filter
- Sizing of the filters of: Butterworth, Bessel, Chebychev I and II, Elliptical. Frequency normalization and denormalization.

**Chapter 2. Time-invariant discrete linear systems**

**(3 weeks)**

- Sampling Reminders
- Z Transform and Reverse Z Transform
- Characteristics of invariant linear discrete systems (linearity, recurrent equation, recursion, time invariance, impulse response, transfer function, causality, stability criterion,...)

**Chapter 3. Analysis and synthesis of digital filters**

**(4 weeks)**

- Digital Filters
- Frequency template
- Structure of the RIF and RII filters
- Stability and implementation of digital filters (RIF and RII)
- Digital filter with minimum phase
- Analysis of RIF and RII filters
- Synthesis of RIF(windowing, frequency sampling)
- Synthesis of RII filters (by impulse invariance, by bilinear transformation)

**Chapter 4. Multi-frame rate digital filters**

**(2 weeks)**

- Undersampling and oversampling
- Multi-rate systems and spectral analysis
- Polyphase filter and decomposition bench
- Multi-speed processing applications

**Chapter 6. Wavelet Transformation (3 weeks)**

- Time-frequency duality and short-term Fourier transform. Cons.
- Continuous, discrete (DWT) and dyadic wavelets
- Examples of DWT (Haar, Daubechies, ... etc)
- Multi-resolution analysis
- Facelift version of the DWT
- Application examples

**Evaluation method:**

Continuous assessment: 40%; Examination: 60%.

**Bibliographical references:**

- [1]. J. G. Proakis and D. G. Manolakis, *Digital Signal Processing: Principles, Algorithms and Applications*. Third Edition, Macmillan, 1996.
- [2]. A. V. Oppenheim, R. W. Schaffer: *Discrete-time signal processing*, Prentice Hall, 1999, 2nd edition
- [3]. M. Bellanger: *Digital Signal Processing: Theory and Practice*, 8th edition, Dunod, 2006.
- [4]. Messaoud Benidir: *Basic Methods for Signal Analysis and Processing*, Dunod, 2004.
- [5]. Y. Mori, "Filtering numérique". Vol. IV, Hermès-Lavoisier. 2006
- [6]. Y. Mori, "Digital Filtering in Signal Processing - Exercises and Practical Work". Hermès-Lavoisier.
- [7]. M., "Traitement Numérique des Signaux", Dunod, Paris, 1981;
- [8]. D.Schlichthärle, "Digital Filters Basics and Design" 2e edition, Springer, 2011 ;
- [9]. [9]. F. Cottet, *Signal Processing and Data Acquisition - Corrected Courses and Exercises*, 4th edition, Dunod, Paris, 2015.

**Semester: 1**  
**Teaching unit: UEF 1.1.2**  
**Subject 4: Industrial Metrology**  
**VHS: 45h00 (Lecture: 1h30, TD: 1h30)**  
**Credits: 4**  
**Coefficient: 2**

### **Teaching objectives:**

At the end of this subject, the student will normally be able to validate a process, to make the necessary parameter adjustments as part of the control of a manufacturing process or to define the safety conditions of a product or a system.

### **Recommended prior knowledge:**

- ✓ Electrical and electronic measurements

### **Material content:**

#### **Chapter 1: General information on Industrial Metrology (02 weeks)**

Definition. Vocabulary and role of metrology. Different metrologies (fundamental, scientific, industrial, legal, ... etc.). Role of Metrology in the company. Relationship between metrology and quality. Official international bodies. Metrology standards and recommendations.

#### **Chapter 2: International System of Units. (02 weeks)**

Base units. Symbols. Derived units. Other units. Models of relationships between units of measurement. Measure. Errors and uncertainties. Notions of errors (random, systematic, accidental, "fidelity and accuracy"). Terminology of measurement uncertainties. Methods of evaluating measurement uncertainties. Law of composition of measurement uncertainties.

#### **Chapter 3: Measurement System (03 weeks)**

Principle and characteristics. Calibration. Sensitivity. Precision. Repeatability. Reproducibility. Rangeability. Metrological confirmation. Causes of errors (calibration, sensitivity, linearity, accuracy, repeatability, reproducibility, resolution, hysteresis, etc.) etc.). Error calculations. General methods of measurement. Deviation measurements. Measures by comparison...

#### **Chapter 4: Metrological traceability (03 weeks)**

Definition and interest. Notions of standard. Calibration hierarchies (SI, National Reference, ... etc.), Examples of Chain of Custody. Evaluation of uncertainty balances. Statistical study.

#### **Chapter 5: Metrology and Quality Control (02 weeks)**

Impact of the measure on production. Notion of measurement capability. Methods of reporting compliance. Management and identification of measurement means. Choice of calibration periodicity. Control charts.

#### **Chapter 6: Statistical analysis of the data (03 weeks)**

Statistical dispersion. The average. Other types of average. The median. Variance and standard deviation. Histogram. Construction of a histogram. Least-squares estimation. The normal or Gaussian distribution or distribution. Confidence interval. Criteria of normality.

### **Evaluation method:**

Continuous assessment: 40%; Examination: 60%.

### **Bibliographical references:**

- [1] .Lorenzo Zago, *Bases of Metrology, School of Engineering and Management of the Canton of Vaud, 2012.*
- [2] .P-A. Paratte, *Traité d'électricité, volume XVII, Systèmes de mesure, Presses polytechniques romandes.*
- [3] J. P. Bentley, *Principles of measurement systems, Pearson education, 2005.*
- [4] J. Niard et al, *Electrical Measurements, Nathan, 1981*
- [5] .D. Barchesi, *Mesure physique et Instrumentation, Ellipses 2003.*
- [6] J.P. Holman, *Experimental Methods for Engineers, McGraw-Hill 1994.*
- [7] .<https://langloisp.users.greyc.fr/metrologie/cm/index.html>
- [8] .<http://www.doc-etudiant.fr/Sciences/Physique/Cours-Introduction-a-la-Metrologie-Industrielle-8223.html>FM

**Semester:1**  
**Teaching unit: UEM1.1**  
**Subject1:TP Instrumentation Electronics**  
**VHS: 10:30 pm (TP: 1h30)**  
**Credits: 2**  
**Coefficient: 1**

**Teaching objectives:**

To put into practice the theoretical knowledge learned about the electronic circuits associated with the instrumentation.

**Recommended prior knowledge:**

Instrumentation electronics

**Material content:**

**TP1** Study of a relaxation oscillator: square signal generator and a Monostable.  
**TP2** Study of A/D Conversion (Sampling Time and Sampling Theorem) Shannon, errors of quantization time).  
**TP3** Study of AM, FM and PWM Modulation Circuits  
**TP4** Active filtering, Filter characterization, Realization of a noisy signal generator, Filtering Interfered signals  
**TP5** Study of a PLL Phase-Locked Loop  
**TP6** Study of a voltage-controlled oscillator (VCO)

**Evaluation method:**

Continuous assessment: 100%.

**Bibliographical references:**

- [1] .A.P. Malvino, *Principles of Electronics, 6th edition; Sciences-Sup, Dunod.*
- [2] .J. Millman, *Microelectronics, Ediscience.*
- [3] .J. Encinas, *Phase Locking System (P.L.L): achievements and applications.*
- [4] .H. H. Ouslimani, A. Ouslimani, *Fonctions principales d'électronique, Casteilla, 2010.*
- [5] .F. Milsant, *Cours d'électronique tome 4, Eyrolles, 1994.*
- [6] .G. Metzger, J.P. Vabre, *Electronique des impulsions, Tome 1, 3rd edition, Masson, 1985.*
- [7] .J-D. Chatelain and R. Dessoulavy, *Electronique, Volumes 1 and 2, Dunod.*
- [8] .S. Boubeker, *Electronique des impulsions, OPU, 1999.*

**Semester:1**  
**Teaching unit: UEM1.1**  
**Subject2:TP Sensors in industrial instrumentation**  
**VHS: 10:30 pm (TP: 1h30)**  
**Credits: 2**  
**Coefficient: 1**

**Teaching objectives:**

To put into practice the theoretical knowledge learned about the electronic circuits associated with sensors as well as the study of some of the most common sensors.

**Recommended prior knowledge:**

Industrial Instrumentation Sensors

**Material content:**

**TP1:** Evaluation of a measurement and study of a conditioning circuit based on a tension and a Wheatstone bridge.

**TP2:** Study of an instrumentation amplifier and evaluation of the common mode.

**TP3:** Conditioning a passive sensor (example Pt100)

**TP4:** Conditioning of an active sensor (e.g. thermocouple and weld compensation) cold)

**TP5:** Study of a level sensor

**TP6:** Study of a pressure sensor

**Evaluation method:**

Continuous Assessment: 100%

**Bibliographical references:**

[1] .Georges Asch and Collaborators. *Sensors in industrial instrumentation*, Dunod 2006

[2] .M. Grout. *Industrial Instrumentation: Specification and Installation of Sensors and Control Valves*, Dunod, 2002.

[3] .N. Ichinose, *Practical Guide to Sensors*, Masson

[4] .P. Dassonvalle, *Les capteurs*, Dunod 2013.

**Semester: 1**  
**Teaching Unit: UEM 1.1**  
**Subject 3: Advanced Signal Processing 1/Industrial Metrology Lab**  
**VHS: 10:30 pm (TP: 1h30)**  
**Credits: 2**  
**Coefficient: 1**

**Teaching objectives:**

Hands-on work done in MATLAB to give a hands-on feel to complex theoretical concepts.  
 The practical work of the second part is carried out by the Proteus/ISIS software and experimentally.

**Recommended prior knowledge:**

Mathematics (Probability Theory and Calculation, Complex Analysis ). Deterministic signal theory, Probabilities and statistics. Industrial metrology.

**Content of the material:**

**Advanced Signal Processing 1 – Once a fortnight**

TP1: Analysis, Synthesis (window method) and implementation of a digital RIF filter

TP2: Analysis, Synthesis by bilinear transformation (case of Butterworth and Chebyshev filters) and implementation of a digital RII filter

TP3: Application of digital filtering

TP4: Implementation of a digital filter bench

TP5: Denoising a signal by discrete wavelet transform

**Industrial Metrology Lab – Once a fortnight**

**TP1:** Study of the methods of evaluation of measurement uncertainties.

**TP2:** Study of metrological traceability.

**TP3:** Estimation of the measurement by the least squares method.

**Evaluation method:**

Continuous assessment: 100%.

**Bibliographical references:**

[1] .Mori Yvon, "Random signals and stochastic processes", Lavoisier, 2014.

[2] .N. Hermann, "Probabilités de l'ingénieur: variables aléatoires et simulations Bouleau", 2002.

[3] .M., "Traitement Numérique des Signaux", Dunod, Paris, 1981.

[4] .M. Bellanger, "Digital signal processing: Theory and practice", 8th edition, Dunod, 2006

[5] .Lorenzo Zago, Basics of Metrology, School of Engineering and Management of the Canton of Vaud, 2012.

[6] .P-A. Paratte, Traité d'électricité, volume XVII, Systèmes de mesure, Presses polytechniques romandes.

[7] .J. P. Bentley, Principles of measurement systems, Pearson education, 2005.

[8] .D. Barchesi, Physical Measurement and Instrumentation, Ellipses 2003.

[9] .J.P. Holman, Experimental Methods for Engineers, McGraw-Hill 1994.

**Semester 1**  
**Teaching unit: UEM1.1**

**Material: Industrial actuators**  
**VHS: 45 h 00 (Cours: 1h30, TP: 1h30 )**  
**Credits: 3**  
**Coefficient: 2**

### **Teaching objectives:**

This course aims to provide students with an in-depth understanding of industrial actuators, with a focus on their operation, control, and applications in automated systems. At the end of the module, students will be able to select, design and implement appropriate actuators for various industrial applications.

### **Recommended Prior Knowledge**

Fundamental Electronics 1 and 2, Electrical and Electronic Measurements.

### **Content of the material:**

*The number of weeks displayed is given as an indication. It is obvious that the course leader is not required to strictly respect this sizing or the arrangement of the chapters.*

#### **Chapter 1: Introduction to Industrial Actuators (3 weeks)**

Introduction to Industrial Actuators: Definition, Role and Importance in Automated Systems. Types of industrial actuators: electric, hydraulic, pneumatic, electromagnetic, etc. Main criteria for selecting actuators: power, speed, precision, reliability, cost, etc.

#### **Chapter 2: Electric Actuators Hydraulic and Pneumatic Actuators (6 Weeks)**

Operation of electric actuators: DC motors, stepper motors, servo motors, etc. Basic principles of electromechanical conversion: magnetic force, torque, speed, etc. Electric actuator control: open-loop control, closed-loop control, pulse-width modulation (PWM) techniques, etc.

Operation of hydraulic actuators: hydraulic cylinders, pumps, valves, etc. Operation of pneumatic actuators: pneumatic cylinders, compressors, distributors, etc. Advantages and disadvantages of hydraulic and pneumatic systems compared to electric systems.

#### **Chapter 3: Actuator Command and Control (4 Weeks)**

Industrial actuator control techniques: analog control, digital control, proportional control, sequential control, etc. Control interfaces: position sensors, force sensors, programmable controllers, etc. Actuator feedback and monitoring: fault detection techniques, diagnostics, preventive maintenance, etc.

### **Practical work:**

#### **Recommended Prior Knowledge**

To pass this lab, students should have prior knowledge in the following areas:

- Basic electronics (electrical circuits, electronic components).
- General physics (basic principles of physical measurements).
- Basic mathematics (analysis, statistics).
- Programming skills (for data acquisition and processing).

The practical work will be structured around the following modules:

## TP Industrial Actuators

- **TP5: Exploring Actuators**
- **TP6 : Electric Motor Control**
- **TP7 : Handling Hydraulic Cylinders**
- **TP8 : Pneumatic Cylinder Control**
- **TP9: Data Acquisition Systems**
  - Objective: To design and implement a data acquisition system, integrating actuators into an automated system.
  - Activities: Use of ADCs, signal amplifiers, and filters to acquire and process sensor data and activate actuators.

### **Method of evaluation:**

Continuous assessment (40%), Final exam (60%)

### **Bibliographical references:**

- [1] G. Asch, "Sensors in industrial instrumentation", Dunod, 2010.
- [2] P. Dassonville, "Les Capteurs : Exercices et problèmes correctes", Dunod, 2005.
- [3] T. Lang, "Electronics of Measurement Systems", Masson, 1992.
- [4] G. Asch, "Data acquisition: from sensor to computer", Dunod, 2003.
- [5] F. Cottet, "Signal Processing and Data Acquisition: Courses and Exercises", Dunod, 1999.
- [6] M. Cerr, "Industrial Instrumentation", Volumes 1 and 2; Edition Tech and Doc.
- [7] G. Asch et al. "Data Acquisition", 3rd edition, Dunod, 2011.
- [8] P. Oguic, "Measures and PC", Edition ETSF.
- [9] F. Boudoin, M. Lavabre, "Sensors: main uses", Edition Casteilla, 2007
- [10] "Introduction to Instrumentation and Measurements" par Robert B. Northrop.
- [11] "Sensors and Transducers" par Ian Sinclair.
- [12] "Principles of Measurement Systems" par John P. Bentley.
- [13] "Industrial Instrumentation and Control" par S. K. Singh.

**Semester: S1**

**Teaching Unit: UEM 1.1**

**Subject: Advanced programming in Python**

**VHS: 4:00 p.m. (Cours 1:30 a.m., Ho Chi Minh City 1:30 p.m.)**

**Credits: 2**

**Coefficient: 2**

**Objectives of the material:**

**Targeted skills:**

- Use of computer tools for the acquisition, processing, production and dissemination of information
- Python and project management skills,
- Skills in automation and data visualization.

**Objectives:**

- Deepen the mastery of the Python language and introduce students to the basics of data analysis and artificial intelligence.
- Acquire the basics of solid computer science.
- Learn to program in Python, Excel
- Mastering task automation
- Mastering project management software

**Materials needed:**

- A computer with Python installed,
- Bibliothèques Python : NumPy, Pandas, Scikit-learn, Matplotlib, os.listdir, os.path.exists, os.mkdir, os.rmdir, Matplotlib, Seaborn, Plitly , Request, Beautiful Soup, Tkinter, PyQt, ...
- Tensorflow, PyTorch, ...

**Prerequisites :** Python programming,

**Content of the material:**

**Chapter 1: Reminders on Python Programming (02 Weeks)**

1. Introduction: Basic concepts in computer science and digital tools, installation of Python.
2. Presentation of the notion of operating system: Roles, types (Linux, Woindows, ..) Priority management,
3. Presentations of computer networks (Principle, IP address, DNS, internet, ...)
4. Basic programming: Interactive mode and script mode, Variables, data types, operators. Conditional structures and loops (if, for, while).
5. Functions and Essentials: Predefined functions and creation of functions. Standard modules (math, random). Strings, lists, basic data manipulation.
6. Files, Lists, Tuples, Dictionaries,
7. Exercises:
  - Python Learning Exercises
  - Exercises on how to use the libraries seen in class (Math, Random, NumPy, Pandas,...)
  - ....

**Chapter 2: Programming and Automation (04 weeks)**

1. Task Automation Principles
  - Python libraries for automation:
    - ✓ Pandas and NumPy.
    - ✓ Os, shütil: manipulation of files and folders
    - ✓ Openpyxl or pandas: working with Excel or CSV files
  - Definitions and examples of automation (sending emails,...)
2. File manipulation with Python:
  - Use libraries to:
    - ✓ Browse a folder (os.listdir)
    - ✓ Verify the existence of a file or folder (os.path.exists)

- ✓ Create or delete folders (os.mkdir, os.rmdir)
- ✓ Visualize data: Matplotlib, Seaborn, Plitly
- ✓ Request to react with Application Programming Interface (API)
- ✓ Beautiful Soup for Data Scraping
- ✓ Tkinter, PyQt to visualize graphical data
- Copy or move files with shutil...
- Simple search, sorting, and reporting.
- Serialization and Deserialization (Using the Pickle Module).
- Serialization of objects and processing of large files (streaming).
- ....

### 3. Exercises:

- Using openpyxl and pandas to read, edit, and write Excel or CSV files to:
  - ✓ Create automatic reports
  - ✓ Automatically extract data
  - ✓ ....
- Writing scripts for:
  - ✓ process text files (search, sorting)
  - ✓ Automate engineering calculations
  - ✓ manage simple reports (PDF, Excel)
  - ✓ ....
- Sorting, searching, and insertion sorting algorithms
- Implement a list search function.
- File Operation
- Secure browsing (simple network configuration, password management)
- ....

### Chapter 3: Advanced Excel Learning (02 weeks)

1. Principles of macros and creating a simple macro,
2. Pivot tables,
3. Histograms,
4. Bar charts,
5. Spider,
6. etc.
7. **Excel exercises ....**

### Chapter 4: Learning GanttProject (02 weeks)

1. Introduction to Project Management:
  - What is a project?
  - What are the challenges of managing a project?
  - Interface de GanttProject
2. Tasks (creation, modification, organization)
3. Time management (project start or end dates)
4. Resource Management
5. **Gantt Project Exercises**

## Chapter 4: Advanced Object-Oriented Programming (03 weeks)

1. Code Organization:
  - Custom functions, parameters, return value.
  - Modules, importations et packages.
2. Complex data structures:
  - Lists, tuples, and dictionaries: creation, modification, deletion, traversal.
3. Fundamental concepts of Object-Oriented Programming (OOP):
  - Classes, objects, attributes, and methods.
  - Public, private and protected attributes.
4. Special methods:
  - **Init, S, Repr, Len.**
5. Advanced concepts:
  - Encapsulation, abstraction, inheritance, polymorphism.
  - Advanced heritage, decorators, design patterns, metaclasses.
6. Exercises

## Chapter 5: Introduction to Data for AI (02 weeks)

1. Introduction aux Datasets courants en IA :
  - Iris, MNIST, CIFAR-10, Boston Housing, ImageNet.
2. Data preprocessing for machine learning:
  - Cleaning, normalization, encoding, data separation.
  - Validation croisée (cross-validation).
3. Techniques de Feature Engineering :
  - Selection, feature creation, dimension reduction.
4. Essential libraries for AI model development:
  - scikit-learn, TensorFlow, Keras, PyTorch
5. Exercises

### Practical work:

#### Lab 01: Mastering the basics of programming in Python

*(Control structures, types, loops, simple functions)*

1. Initiation
2. Read and process text files
3. Manage simple reports (PDF, Excel)

#### TP 02 :

- Develop specifications for a mini task automation project with Python consisting of automatically identifying and sending reports by email with Python:

1. Load data from a file (e.g. experimental measurements),
2. Perform simple statistics on the data (mean, standard deviation with interpretation),
3. Generate a graph,
4. Sending the result with Python.

#### TP 03 :

1. Ex Excel programming of the dashboard seen in TD

2. Creating automated Excel tables
3. Simple macros,
4. Conditional formulas,
5. Research V.

**TP 04 :**

Organize a meeting in Ganttproject

1. Create a new project:
  - Project name: "Reunion....."
  - Start date: Date and time of the meeting
  - Estimated Duration: Total duration of the meeting
2. Task Definition
  - Agenda items (each agenda item becomes a task)
  - Subtasks: If a point is composed, then create the corresponding subtasks
  - Initial and final tasks (e.g., "Welcoming participants", "Closing the meeting")
3. Definition of resources:
  - Participants (each participant is a resource)
  - Equipment (computer, datashow, etc.)
4. Estimated durations:
  - Duration of each item: time required for each agenda item
  - Point-to-point transition time
5. Creating the Gantt chart:
  - View the agenda
  - Identify key points
6. Track progress in real time (Gantt Chart projection)

**Lab 05: Advanced Structures and Code Organization**

*( Custom functions, dictionaries, modules and modular organization*

**Lab 06: Advanced Object-Oriented Programming in Python**

*(Encapsulation, inheritance, special methods, simple design patterns)*

**TP 07: File Manipulation and Data Analysis**

*(Read/write files, word processing, introduction to Pandas and NumPy)*

**TP 08: Data preparation and processing for artificial intelligence**

*(Loading AI datasets, cleaning, transforming, feature selection)*

**Final project**

**Title:** Analysis and visualization of a dataset + simple predictive model

**Skills mobilized:** Data reading, OOP, advanced structures, Pandas, Scikit-learn. (Oral presentation + written report).

**Method of evaluation:**

**exam 60% , CC=40%**

**Bibliography**

- [1] .E.Schultz and M.Bussonnier (2020): Python for the SHS. Introduction to Data Programming. Presses Universitaires de Rennes.

- [2] .C.Paroissin, (2021): Data science practice with R: arranging, visualizing, analyzing and presenting data. Paris: Ellipses, DL 2021.
- [3] .S.Balech and C.Benavent: NLP text minig V4.0, (Paris Dauphine – 12/2019): link: [https://www.researchgate.net/publication/337744581\\_NLP\\_text\\_mining\\_V40\\_-\\_une\\_introduction\\_-\\_cours\\_programme\\_doctoral](https://www.researchgate.net/publication/337744581_NLP_text_mining_V40_-_une_introduction_-_cours_programme_doctoral)
- [4] .Allen B. Downey Think Python: How to Think Like a Computer Scientist, O'Reilly Media, 2015;
- [5] .Ramalho, L.. Fluent Python. " O'Reilly Media, Inc.", 2022;
- [6] .Swinnen, G.. Learn to program with Python 3. Editions Eyrolles, 2012;
- [7] .Matthes, E. Python crash course: A hands-on, project-based introduction to programming. no starch press, 2019
- [8] .Cyrille, H. (2018). Learn to program with Python 3. Eyrolles, 6th edition. ISBN: 978-2212675214
- [9] .Daniel, I. (2024). Learn to code in Python, I've read
- [10] . Nicolas, B. (2024). Python, from the complete beginner to object programming Corrected courses and exercises, 3rd edition, Ellipses
- [11] . Ludivine, C. (2024). Selenium Master your functional tests with Python, Eni

**Online resources:**

- Official Python documentation: [docs.python.org](https://docs.python.org)
- Exercices Python sur Codecademy : [codecademy.com/learn/learn-python-3](https://codecademy.com/learn/learn-python-3)
- W3Schools Python Tutorial : [w3schools.com/python/](https://w3schools.com/python/)

**IV - Detailed programme by subject of the S2 semester**

**Semester: 2**  
**Teaching unit: UEF 1.2.1**  
**1 Material: Microcontrollers & DSP**  
**VHS: 67h30 (Lecture: 3h00, TD: 1h30)**  
**Credits: 6**  
**Coefficient: 3**

**Teaching objectives:**

To know the operation and internal architecture of dsPICs, which are the integration of the DSP multiplier into a microcontroller. Learn their programming and know the techniques used for the implementation of digital signal processing algorithms.

**Recommended prior knowledge:**

Microprocessor systems. Digital signal processing. Programming in assembly language.

**Content of the material:**

**Chapter 1: dsPIC Microcontroller Basics (2 weeks)**

- Introduction to 8-bit, 16-, and 32-bit PIC microcontrollers.
- Overview of the 16-bit series; especially the dsPIC33F/PIC24H.
- Core CPU architecture.
- Organization of memories: program and data.
- Hardware-based outage management.
- Basic Configuration: Configuration Bits, Oscillators, Reset Circuit, Watchdog.
- I/O port management.

**Chapter 2: Programming dsPIC Microcontrollers (4 weeks)**

- Assembler instruction set.
- Introduction to embedded C programming with MPLAB-XC16.
- Handling registers including I/O ports in assembler, XC16 and assembler inside the XC16.
- Management of timer devices.

**Chapter 3: Interfacing Sensors with dsPIC Microcontrollers (4 weeks)**

- Analog-to-digital conversion.
- Implementation of digital filtering of measurements in dsPICs.
- Practical example of hardware/firmware development of:
  - o Temperature measurement.
  - o Pressure and weight measurement with strain gauges.
  - o Measurement of liquid flow rates and levels.

**- Chapter 4: Other dsPIC Microcontroller Hardware Devices (4 weeks)**

- I/O capture/compare management for speed measurement.
- Control of the rotation speed of the motors in PWM.
- Communication: UART, SPI and I<sup>2</sup>C.

**Evaluation method:**

Continuous assessment: 40%; Examination: 60%.

**Bibliographical references:**

- [1] .Lucio Di Jasio « Programming 16-bit PIC microcontrollers in C : Learning to fly the PIC 24 », 2nd edition, Elsevier, 2012.
- [2] .Creed Huddleston « Intelligent sensor design using the Microchip dsPIC® », Elsevier, 2007.

- [3] J.M. Angulo Usategui, A. Etxebarria Ruiz, I. Angulo Martínez, I. Trueba Parra « *Microcontrollers dsPIC :D design práctico de aplicaciones* » Spanish Edition, McGraw-Hill 2006.
- [4] Armstrong Subero « *Programming PIC microcontrollers with XC8* », Apress 2018.
- [5] Microchip, « *16-Bit MCU and DSC Programmer's Reference Manual: High-Performance Microcontrollers (MCU) and Digital Signal Controllers (DSC)* », (DS70000157G),
- [6] Microchip, « *MPLAB® C compiler for PIC24 MCUs and dsPIC® DSCs user's guide* » (DS51284),
- [7] Microchip, « *MPLAB® Assembler, Linker and utilities for PIC24 MCUs and dsPIC® DSCs user's guide* » (DS51317H),
- [8] Microchip, « *dsPIC33F/PIC24H Family Reference Manual* » (DS70197C),  
<https://www.microchip.com/doclisting/TechDoc.aspx?type=ReferenceManuals>
- [9] Microchip, « *dsPIC33F/PIC24H Section 2 : CPU* » (DS70204),
- [10] Microchip, « *dsPIC33F/PIC24H Section 3 : Data Memory* » (DS70202),
- [11] Microchip, « *dsPIC33F/PIC24H Section 4 : Program Memory* » (DS70203),
- [12] Microchip, « *dsPIC33F/PIC24H Section 5 : Flash Programming* » (DS70191),
- [13] Microchip, « *dsPIC33F/PIC24H Section 6 : Interrupts* » (DS70184),
- [14] Microchip, « *dsPIC33F/PIC24H Section 7 : Oscillator* » (DS70186),
- [15] Microchip, « *dsPIC33F/PIC24H Section 8 : Reset* » (DS70192),
- [16] Microchip, « *dsPIC33F/PIC24H Section 9 : Watchdog Timer and Power-Saving Modes* » (DS70196),
- [17] Microchip, « *dsPIC33F/PIC24H Section 25 : Device Configuration* » (DS70194),
- [18] Microchip, « *dsPIC33F/PIC24H Section 10 : I/O Ports* » (DS70193),
- [19] Microchip, « *dsPIC33F/PIC24H Section 11 : Timers* » (DS70205),
- [20] Microchip, « *dsPIC33F/PIC24H Section 12 : Input Capture* » (DS70198),
- [21] Microchip, « *dsPIC33F/PIC24H Section 13 : Output Compare* » (DS70209),
- [22] Microchip, « *dsPIC33F/PIC24H Section 14 : Motor Control PWM* » (DS70187),
- [23] Microchip, « *dsPIC33F/PIC24H Section 15 : Quadrature Encoder Interface (QEI)* » (DS70208),
- [24] Microchip, « *dsPIC33F/PIC24H Section 16 : Analog-to-Digital Converter (ADC)* » (DS70183),
- [25] Microchip, « *dsPIC33F/PIC24H Section 17 : UART* » (DS70188),
- [26] Microchip, « *dsPIC33F/PIC24H Section 18 : Serial Peripheral Interface (SPI)* » (DS70206),
- [27] Microchip, « *dsPIC33F/PIC24H Section 19 : Inter-Integrated Circuit™ (I2C™)* » (DS70195).

**Semester: 2**  
**Teaching unit: UEF 1.2.1**  
**Subject 2: Digital servo systems**  
**VHS: 45h00 (Lecture: 1h30, TD: 1h30)**  
**Credits: 4**  
**Coefficient: 2**

### **Teaching objectives:**

The objective of this course is to address some aspects of the numerical control of linear dynamical systems. Introduce the properties and representations of discrete-time linear dynamical systems. Analysis, improvement of the performance of numerical servo systems Starting from physical processes modeled by transfer functions in  $p$ (Laplace variable), we will successively approach the modeling of discrete and sampled systems, their analysis and finally the synthesis of numerical control laws.

### **Recommended prior knowledge:**

- ✓ Signal theory;
- ✓ Mathematical aspects such as the manipulation of functions and sequences, integral calculus and series and the Laplace transform;
- ✓ The automation of continuous-time linear servo systems;
- ✓ Method of synthesis of correctors;

### **Content of the material:**

#### **Chapter 1. Modeling of Sampled Signals and Systems (3 weeks)**

Sampling and reconstitution of signals: Definition, sampled signal and CAN, Shannon's theorem and zero-order and one-order blocker and CNA. Z transform of sampled signals: Definition, properties of the transform in  $z$ , function of sampled transfers, recurrent equation, inverse transform  $z$ . Relationships between continuous-time and discrete-time models: forward discretization, backward discretization, and bilinear transformation (Tustin).

#### **Chapter 2. Performance Analysis of Digital Servo Systems (4 weeks)**

Equation of sampled servos: Closed-loop transfer function, Transfer function of complex systems, continuous-discrete time relationship in closed loop. Stability of sampled servos: mathematical criterion of stability, Algebraic jury criterion, Routh criterion, frequency analysis of stability, Influence of sampling frequency on stability. Accuracy of sampled servos: Position and velocity errors, Accuracy of a sampled system of class  $\in \{0,1,.. \}$ .

#### **Chapter 3. Analyzing Sampled Systems in the State Space (4 weeks)**

Discretization of the equation of state of a continuous system: Relationship between the equation of state of a continuous system and that of a discrete system. Representation and Solving the Equation of State of a Discrete System: Different Forms of the Evolution Matrix (Diagonal, Companion, Observer, Controller, Observability, and Controllability). Stability and accuracy of a discrete system: Roots of the characteristic equation, controllable modes, observable modes from the state representation of the sampled systems. Notions of governability and observability for SISO and MIMO systems.

#### **Chapter 4. Correction of digital servo systems (4 weeks)**

Role of the corrector, numerical correction of a continuous-time system, compensation of the loss of stability by placement of the poles, synthesis of a numerical corrector by discretization of a continuous corrector, Synthesis of a numerical corrector by polynomial method.

### **Method of evaluation:**

Continuous assessment: 40%; Examination: 60%.

**Bibliographical references :**

- [1] .P. Borne, G. Dauphin-Tanguy, J.P. Richard, F. Rotella, and I. Zambettakis. *Analysis and Regulation of Industrial Processes. Volume 1: Continuous Regulation.* Technip, France, 1993. ;
- [2] .B. by Andréa Novel and M. Cohen by Lara. *Linear Control of Dynamic Systems.* Masson, France, 1994;
- [3] .E. Dieulesaint and D. Royer. *Applied Automation: 2. Linear Control Systems with Sampled Signals* Masson, France, 1990. ;
- [4] .R.C. Dorf and R.H. Bishop. *Modern Control Systems.* Addison-Wesley Publishing Company, Inc., New-York, 1995;
- [5] .D. Jaume, S. Thelliez, and M. Vergé. *Control of Dynamic Systems by Computer.* Eyrolles, France, 1991;
- [6] .B. Pradin. *DISCRETE TIME SYSTEMS - Numerical process control.* INSA Toulouse, France, 1999. ;
- [7] .R. Longchamp, 'Numerical control of dynamic systems', *Presses Polytechniques et Universitaires Romandes*, 2006;

**Semester: 2**  
**Teaching unit: UEF 1.2.2**  
**Subject 3: Advanced Digital Electronics: VHDL and FPGA**  
**VHS: 45h00 (Lecture: 1h30, TD: 1h30)**  
**Credits: 4**  
**Coefficient: 2**

**Teaching objectives:**

In this subject, students will have to study the different types of programmable circuits, as well as the different design methods in particular programming using hardware description languages.

The content of this subject is applied at the level of the subject "UEM1.1: TP FPGA & VHDL".

**Recommended prior knowledge:**

Digital electronics (combinatorial and sequential).

**Material content:**

**Chapter 1. Programmable Circuit Basics (1 weeks)**

- General Architecture of Programmable Logic Circuits: PAL, GAL, PLD, CPLD
- Examples of manufacturers and programming tools: Altera Quartus II, Xilinx ISE

**Chapter 2. VHDL programming (5 weeks)**

- History of the VHDL.
- Comparison between VHDL and programming languages.
- Different descriptions of an architecture: data flow, behavioral, structural.
- Identifiers and capitalization sensitivity.
- Comments.
- Representation of numbers in VHDL
- General structure of a VHDL code: Library, Entity, Ports, Architecture.
- Data types: Predefined, user-defined
- Operators: Logic, Relational, Offset, Concatenation
- Signal attributes: EVENT, ...
- Signal, variable and constant
- Process
- Component
- Instruction IF-THEN-ELSE
- Instruction CASE-WHEN
- Instruction WHEN-ELSE
- Instruction WITH-SELECT-WHEN

**Chapter 3. Applications on FPGA Circuits (5 weeks)**

- Multiplexer
- Bascule D
- Adder
- Universal counter with actions: activation, reset, load.
- Frequency divider.
- Frequency management with buttons: selection, division
- 7-segment decoder,
- Serial display on several 7 segments.
- 8-bit arithmetic-logical unit
- 8-bit comparator

**Chapter 4. Advanced Design with Finite State Number Machines (FSM)****(4 weeks)**

- Introduction: Mealy and Moore structure
- Representation of an FSM machine
- FSM Design Examples

**Evaluation method:**Exam: **60%**, Continuous assessment: **40%****Bibliographical references:**

- [1]. Volnei A. Pedroni, « *Circuit Design with VHDL* », MIT Press, 2004.
- [2]. Volnei A. Pedroni, « *Circuit Design and Simulation with VHDL* », 2ème édition, MIT Press, 2010.
- [3]. Bryan Mealy, Fabrizio Tappero, « *Free Range VHDL* », 2018
- [4]. Pong P. Chu, « *FPGA prototyping by vhdlexamples : Xilinx Spartan™-3 Version* », John Wiley & Sons, 2008.
- [5]. Jacques Weber, Sébastien Moutault, Maurice Meaudre, "The VHDL language: from language to the circuit, from the circuit to language", Dunod, 2007.
- [6]. Christian Tavernier, "Programmable Logic Circuits", Dunod 1992.

**Semester: 2**  
**Teaching unit: UEF 1.2.2**  
**Subject 4: Advanced Signal Processing 2**  
**VHS: 45h00 (Lecture: 1h30, TD: 1h30)**  
**Credits: 4**  
**Coefficient: 2**

### **Teaching objectives:**

This course is designed to enable students to:

- ✓ Understand the concepts of discrete random processes
- ✓ Develop the mathematical theory of various realizations of linear adaptive filters

### **Recommended prior knowledge:**

This course assumes that the student has some knowledge of:

- ✓ Probability and statistics
- ✓ Random processes
- ✓ Digital Filters
- ✓ Discrete Time Signals and Systems
- ✓ Matrix algebra.

### **Material content:**

#### **Chapter 1: Random Signals and Stochastic Processes (3 weeks)**

- Reminder about random processes
- Reminder of the concepts: mean, autocorrelation and stationarity
- Power spectral density
- Notions of stochastic processes
- Stationarities in the broad and strict sense and Ergodicity
- Examples of stochastic processes (Poisson process, Gaussian process and Markov process)
- Higher-order statistics (Moments and cumulants, Polyspectra, non-Gaussian processes, nonlinear processing)

#### **Chapter 2. Discrete random processes and patterns (4 weeks)**

- Discrete-time stochastic processes
- The correlation matrix (definition and properties)
- Stochastic models (AR, MA, ARMA)
- The Yule-Walker equations

#### **Chapter 3. Optimal linear filtering (4 weeks)**

- Wiener Filtering: Filtering Problem Formulation, Orthogonality Principle, Wiener-Hopf Equation, Root Mean Square Error Area, Minimum Root Mean Square Error (RMSE)
- Linear prediction: Linear prediction forward, Linear prediction backward, Levinson-Durbin algorithm
- Prediction error

#### **Chapter 4. Adaptive Digital Filtering Algorithms (4 weeks)**

- Steepestdescent deterministic gradient algorithm
- Least-Mean Square (LMS) Algorithm
- Variants of the LMS algorithm
- Recursive least-squares (RLS) algorithm

**Evaluation method:**

Continuous assessment: 40%; Examination: 60%.

**Bibliographical references:**

- [1] .S. Haykin, "Adaptive Filter Theory", 5<sup>e</sup> édition, Pearson Prentice Hall, 2014;
- [2] J. G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms and Applications". Third Edition, Macmillan, 1996.
- [3] J. G. Boroujeny, Adaptive Filters: Theory and Applications. John Wiley and Son, 1998.
- [4] . A. Antoniou, "Digital Filters Analysis, Design, and Signal Processing Applications", McGraw-Hill, 2018;
- [5] .P. Stoica et R. Moses, "Spectral Analysis of Signals", Pearson Prentice Hall, 2005;
- [6] . F. Cottet, Signal Processing and Data Acquisition - Corrected Courses and Exercises, 4<sup>th</sup> edition, Dunod, Paris, 2015.

**Semester: 2**  
**Teaching unit: UEM 1.2**  
**Material 1: TP Microcontrollers & DSP**  
**VHS: 10:30 pm (TP: 1h30)**  
**Credits: 2**  
**Coefficient: 1**

**Teaching objectives:**

Put into practice the theoretical knowledge learned in the course through the design of different applications and programming with a focus on assembler to fully understand the internal architecture of dsPIC and embedded C to achieve objectives quickly.

**Recommended prior knowledge:**

Programming language, microprocessors.

**Material content:**

**TP1:** MPLAB X / Proteus simulation development environment: Creation of LED flashing projects with the MCC (MPLAB® Code Configurator) graphical tool.

**TP2:** Management of I/O ports in Assembler: configuration, write, read.

**TP3-4:** Debugging program memory and data memory (handling special registers such as STATUS, and controlling I/O ports such as TRIS/LATCH/PORT).

**TP5-6:** Programming the same previous operations in XC16, and comparing compilation results in terms of optimization.

**TP7:** Configuration of the ADC module in assembler and C.

**TP8-9:** Measurement of an analogue quantity according to the existing equipment in the establishment, otherwise in simulation (temperature, pressure, flow, speed, etc.) and display of the measurement result on 4x7 segments (to clearly see the instability of the display of the last character).

**TP10-11: Real-time** digital filtering of measurement noise and display of the result on 4x7 segments and LCD.

**TP12-15:** Application of a speed servo of a motor while integrating a communication protocol; example of storage of measured data on a PC.

**Evaluation method:**

Continuous Assessment: 100%

**Bibliographical references:**

[1] .Lucio Di Jasio « Programming 16-bit PIC microcontrollers in C : Learning to fly the PIC 24 », 2nd edition, Elsevier, 2012.

- [2]. Creed Huddleston « *Intelligent sensor design using the Microchip dsPIC®* », Elsevier, 2007.
- [3]. J.M. Angulo Usategui, A. Etxebarria Ruiz, I. Angulo Martínez, I. Trueba Parra « *Microcontrollers dsPIC :D design práctico de aplicaciones* » Spanish Edition, McGraw-Hill 2006.
- [4]. Armstrong Subero « *Programming PIC microcontrollers with XC8* », Apress 2018.
- [5]. Microchip, « *16-Bit MCU and DSC Programmer's Reference Manual: High-Performance Microcontrollers (MCU) and Digital Signal Controllers (DSC)* », (DS7000157G),
- [6]. Microchip, « *MPLAB® C compiler for PIC24 MCUs and dsPIC® DSCs user's guide* » (DS51284),
- [7]. Microchip, « *MPLAB® Assembler, Linker and utilities for PIC24 MCUs and dsPIC® DSCs user's guide* » (DS51317H),
- [8]. Microchip, « *dsPIC33F/PIC24H Family Reference Manual* » (DS70197C),  
<https://www.microchip.com/doclisting/TechDoc.aspx?type=ReferenceManuals>
- [9]. Microchip, « *dsPIC33F/PIC24H Section 2 : CPU* » (DS70204),
- [10]. Microchip, « *dsPIC33F/PIC24H Section 3 : Data Memory* » (DS70202),
- [11]. Microchip, « *dsPIC33F/PIC24H Section 4 : Program Memory* » (DS70203),
- [12]. Microchip, « *dsPIC33F/PIC24H Section 5 : Flash Programming* » (DS70191),
- [13]. Microchip, « *dsPIC33F/PIC24H Section 6 : Interrupts* » (DS70184),
- [14]. Microchip, « *dsPIC33F/PIC24H Section 7 : Oscillator* » (DS70186),
- [15]. Microchip, « *dsPIC33F/PIC24H Section 8 : Reset* » (DS70192),
- [16]. Microchip, « *dsPIC33F/PIC24H Section 9 : Watchdog Timer and Power-Saving Modes* » (DS70196),
- [17]. Microchip, « *dsPIC33F/PIC24H Section 25 : Device Configuration* » (DS70194),
- [18]. Microchip, « *dsPIC33F/PIC24H Section 10 : I/O Ports* » (DS70193),
- [19]. Microchip, « *dsPIC33F/PIC24H Section 11 : Timers* » (DS70205),
- [20]. Microchip, « *dsPIC33F/PIC24H Section 12 : Input Capture* » (DS70198),
- [21]. Microchip, « *dsPIC33F/PIC24H Section 13 : Output Compare* » (DS70209),
- [22]. Microchip, « *dsPIC33F/PIC24H Section 14 : Motor Control PWM* » (DS70187),
- [23]. Microchip, « *dsPIC33F/PIC24H Section 15 : Quadrature Encoder Interface (QEI)* » (DS70208),
- [24]. Microchip, « *dsPIC33F/PIC24H Section 16 : Analog-to-Digital Converter (ADC)* » (DS70183),
- [25]. Microchip, « *dsPIC33F/PIC24H Section 17 : UART* » (DS70188),
- [26]. Microchip, « *dsPIC33F/PIC24H Section 18 : Serial Peripheral Interface (SPI)* » (DS70206),
- [27]. Microchip, « *dsPIC33F/PIC24H Section 19 : Inter-Integrated Circuit™ (I2C™)* » (DS70195),

**Semester : 2**

**Teaching unit: UEM 1.2**

**Subject 2: Practical work Digital servo systems. / TP Advanced Signal Processing 02**

**VHS: 10:30 p.m. (TP: 1h30)**

**Credits: 2**

**Coefficient : 1**

**Teaching objectives:**

Apply the theoretical knowledge learned in the Digital Servo Systems and Advanced Signal Processing 2 courses.

**Recommended prior knowledge:**

- ✓ Programming of digital circuits;
- ✓ The automation of digital servo systems;
- ✓ Signal processing.

**Content of the material:**

**TP Digital Servo Systems – Once a fortnight**

**TP1: Modeling a Physical System with Simulink/Matlab**

Modeling a DC machine (or a permanent magnet synchronous machine, a chemical process, etc.). Linearization by a discrete model (use of Matlab *dlinmod*, *trim commands*, etc.), Comparison of model/system temporal responses for different excitations using Simulink/Matlab blocks.

**TP2: Analysis of a sampled system**

Application of some transformations on the model of **TP1** (use of commands: *canon*, *bilin*, *c2dm*, *d2cm ssdata*, *tfddata*, *ss2ss*, etc.). Examining controllability and observability (*ctrb*, *obsv commands*)

**TP3: Modeling and correction by discrete state representation**

Modeling and synthesis of control laws from the state representation of the physical system of **TP1** (commands: *dreg*, *dlqr*, etc.). Examination of the frequency responses of the corrected system (commands: *dbode*, *dnyquist*, *dsigma*, etc.).

**TP4: Implementation of Sampled Controllers**

Use Simulink to implement control laws (by state feedback, by output feedback) or standard sampled controllers (P, PI, PID). Examination of the looped system's temporal responses for different inputs of the setpoint, disturbance and measurement noise

**Advanced Signal Processing 02 Lab – Once a fortnight**

**Lab 1:** Simulation of random signals, Calculation of power spectral density, Calculation of the auto-correlation and inter-correlation function.

**Lab 2:** Filtering random signals.

**Lab 3:** Spectral analysis of random signals.

**TP4:** Parametric AR and/or ARMA spectral analysis of sound signals (example of non-audible signals) stationary)

**TP5:** Elimination of 50Hz interference by the LMS gradient algorithm

**Method of evaluation:**

Continuous assessment: 100%.

**Bibliographical references :**

- [1] .P. Borne, G. Dauphin-Tanguy, J.P. Richard, F. Rotella, and I. Zambettakis. *Analysis and Regulation of Industrial Processes. Volume 1: Continuous Regulation. Technip, France, 1993;*
- [2] .J. L Abatut, *Sampled Linear Systems and Servoing, Edition Dunod.*
- [3] .H. Buhler, *Sampled Adjustments Volume 1, Edition Dunod.*
- [4] .B. by Andréa Novel and M. Cohen by Lara. *Linear Control of Dynamic Systems. Masson, France, 1994;*
- [5] .E. Dieulesaint and D. Royer. *Applied Automation: 2. Linear Control Systems with Sampled Signals Masson, France, 1990. ;*
- [6] .D. Jaume, S. Thelliez, and M. Vergé. *Control of Dynamic Systems by Computer. Eyrolles, France, 1991;*
- [7] .B. Pradin. *DISCRETE TIME SYSTEMS - Numerical process control. INSA Toulouse, France, 1999.*
- [8] .1. S. Haykin, "Signals and systems", John Wiley & sons, 2ed, 2003.
- [9] .2. A.V. Oppenheim, "Signals and systems", Prentice-Hall, 2004.
- [10] . 3. Mori Yvon, "Random Signals and Stochastic Processes", Lavoisier, 2014
- [11] . 4. A. Papoulis, "Probability, Random variable and Stochastic Processes", Mc Graw Hill 1984.
- [12] . 5. E. Robine, "Introduction to the theory of communication, Volume II: Random signals", Masson 1970.
- [13] . 6. N. Hermann, "Engineer's Probabilities: Random Variables and Birch Simulations", 2002.
- [14] . 7. Ruegg, Alan, "Stochastic Process", Lausanne: Presses polytechniques et universitaires romandes, 1989.

**Semester: 2**  
**Teaching unit: UEM 1.2**  
**Material 3: TP VHDL – FPGA**  
**VHS: 10:30 pm (TP: 1h30)**  
**Credits: 2**  
**Coefficient: 1**

**Teaching objectives:**

The practical work should allow the theoretical elements covered in class to be put into practice.

**Recommended prior knowledge:**

Digital electronics. Industrial communication networks and protocols.

**Material content:**

**TP1:** Presentation of the development and simulation tool: Altera Quartus II or Xilinx ISE.

**TP2:** Exploitation of the development map through a given example of an adder.

**TP3:** First circuit examples: multiplexer, D flip-flop.

**TP4:** Simple 48-bit decimal counter.

**TP5:** 48-bit decimal counter with actions: activate, reset, charge.

**TP6:** Road traffic light.

**TP7:** Multiplier/divider with shift registers.

**TP8:** Serial display on several 7 segments.

**TP9:** Digital clock.

**TP10:** Frequency division.

**TP11:** Frequency division controllable with buttons.

**TP12:** VGA display.

**Evaluation method:**

Continuous Assessment: 100%

**Bibliographical references:**

[1]. J. Weber, Sébastien Moutault, Maurice Meaudre, "Le langage VHDL : du langage au circuit, du circuit au langage", Dunod, 2007.

[2]. C. Tavernier, "Circuits logiques programmables", Dunod 1992.

[3]. Volnei A. Pedroni, « Circuit Design with VHDL », MIT Press, 2004.

[7]. Volnei A. Pedroni, « Circuit Design and Simulation with VHDL », 2ème édition, MIT Press, 2010.

[8]. Bryan Mealy, Fabrizio Tappero, « Free Range VHDL », 2018

[9]. Pong P. Chu, « FPGA prototyping by vhdlexamples : Xilinx Spartan™-3 Version », John Wiley & Sons, 2008.

[10]. Jacques Weber, Sébastien Moutault, Maurice Meaudre, "The VHDL language: from language to the circuit, from the circuit to language", Dunod, 2007.

[11]. Christian Tavernier, "Programmable Logic Circuits", Dunod 1992.

**Semester: 2**

**Teaching unit: UEM 1.2****Subject 4: Project-based learning****VHS: 4:00 p.m. (Cours: 1:30 a.m., Ho Chi Minh City: 1:30 a.m.)****Credits: 3****Coefficient: 2****Teaching objectives:**

Analyze specifications. Implement and methodically conduct an electronic production project. To make the student aware of the time management of the project. Learn how to validate a technical solution. Write technical documents.

**Recommended prior knowledge:**

Know how to find, use and produce technical documentation for a project.

**Material content:**

1. Analyze an existing technical solution.
2. Search for documents and use information.
3. Managing a project: specifications, technical choices, cost, schedule, planning of the execution of the work, management of the constraints of the specifications and the quality approach.
4. Implement hardware and software components using the manufacturers' manuals.
5. Design all or part of a block or structural diagram, an algorithm and its associated coding, a sequencer and its associated coding.
6. Make a prototype.
7. Validate a technical solution (measurements or simulations) in accordance with specifications,
8. Write technical documents associated with the project.

**General information:**

From the beginning of the semester, students are asked to choose a project (at the master's level) from a list provided by the subject supervisor or to propose their own project (which must have the prior approval of the subject supervisor).

**Evaluation method:**

Continuous assessment: 40%; Examination: 60%.

**Bibliographical references:**

- [1] .H. Prevost, *Project Management, Technip*, 1996.  
 [2] .I. Chvidchenko, *Conduite et gestion des grands projets, Cepadues*, 1993.  
 [3] .V. Giard, *Gestion de projet, Economica*, 1991.  
 [4] .M. Joly & J.L.G. Muller, *De la gestion de projet au management par projet, Afnor*, 1994.  
 [5] .G.M. Caupin & J. Le Bissonnais, *Conducting an investment project, Afnor - A Savoir*, 1996.  
 [6] .Manufacturer documentation (Data Books).

**Semester: S2**

**Teaching unit: UET 1.2.1**

**Subject: Elements of applied artificial intelligence**

**VHS: 4:00 p.m. (Cours 1:30 a.m., Ho Chi Minh City 1:30 p.m.)**

**Credits: 2**

**Coefficient: 2**

**Targeted skills:**

- Identifying opportunities for artificial intelligence in engineering sciences
- Understand the ethical implications of AI and the best practices for its use.
- Ability to use AI techniques in problem solving

**Objectives:**

- Mastery of AI algorithms
- Introduction to the fundamental concepts, tools, and applications of modern artificial intelligence, with an emphasis on practice with Python and its libraries.
- Deepen the Python language,
- Understand AI approaches to problem solving,

**Prerequisites :**

Advanced Python Programming

**Materials needed:**

- A computer with Python installed,
- Bibliothèques Python : NumPy, Pandas, Scikit-learn, Matplotlib, os.listdir, os.path.exists, os.mkdir, os.rmdir, Matplotlib, Seaborn, Plitly , Request, Beautiful Soup, Tkinter, PyQt, ...
- Tensorflow, PyTorch, ...

**Content of the material:**

**Chapter 1: Introduction to Artificial Intelligence AI (01 week)**

1. Definitions and scopes of AI.
2. Historical evolution of AI.
3. Introduction to the main areas:
  - Machine Learning
  - Deep Learning

**Chapter 2: Basic Mathematics for AI (01 week)**

1. **Linear algebra** : vectors, matrices, products, norms.
2. **Probability & Statistics** :
  - Variables, expectancy, variance.
  - Usual laws: normal, binomial, uniform.
3. **Simple linear regression** :
  - Formulation, cost, optimization.
  - Implementation with **Scikit-learn**.
4. **Exercises:**
  - Manipulating Matrices with the NumPy Library (Python)
  - Exercise on linear regression (use a Python library like Scikit-learn for example)
  - Explain the Matplotlib library (Python)
  - ...

### Chapter 3: Machine Learning (03 weeks)

1. Key concepts: Data, Models, features, labels, generalization.
2. Phases of a learning pipeline: training, validation, testing.
3. Types of learning:
  - Supervised
  - Unsupervised
  - By reinforcement (*preview*)
4. **Exercises:**
  - Deepen the concepts seen in the course
  - ....

### Chapter 4: Supervised Classification (3 weeks)

1. Simple classification model training principle:
2. Models and algorithms:
  - SVM (Support Vector Machine)
  - Decision trees
3. Performance evaluation:
  - Confusion matrix, accuracy, recall, F1-score.
5. **Exercises:**
  - Explain how to use Scikit-learn?
  - Comparing Multiple Models on a Dataset
  - ....

### Chapter 5: Unsupervised Learning

1. Notion de clustering.
2. Algorithms:
  - **K-means**
  - DBSCAN (Density-Based Spatial Clustering of Applications with Noise)
3. 2D visualization and interpretation of results.
4. **Exercises:**
  - Explain how to use a clustering algorithm on a Dataset
  - Explain how to visualize clusters.
  - ....

### Chapter 6: Neural Networks

1. Architecture of a neural network:
  - Perception,
  - Layers and hidden layers, weights, biases.
  - Activation function: ReLU, Sigmoid, Softmax, ....
  - Application exercises
2. Introduction to **Deep Learning** :
  - Notion of deep layers.
  - Introduction to Convolutional Networks (CNN)
3. **Exercises** :
  - Explain Tensorflow and PyTorch

- Analyze a Text Dataset and Predict Sentiment
- ....

## Chapter 6: Introduction Neural Networks

### Chapter 7: Mini project (supervised personal work outside of class):

Creation of a complete classification or clustering model, with preprocessing, training and visualization; Select and process a project from start to finish from (to be distributed at the beginning of the semester):

- Handwriting Recognition
- Prediction of natural disasters
- Develop a Chatbot that can answer a company's frequently asked questions, in a natural way.
- Develop a system capable of distinguishing normal sounds of a machine from those indicating an anomaly (defective bearing, excessive vibration, etc.)
- Develop a system (mini AI) capable of analyzing the sentiments expressed in social media posts about a product, brand or event.
- ...

### Practical work :

#### TP 01: Initialization

#### TP 02 :

- Implementing a simple regression with Scikit-learn visualization with Matplotlib (for example)
- Visualize the results with Matplotlib
- ...

#### TP 03 :

- **Machine learning pipeline and data separation**
- Deepen the concepts seen in the course

#### TP 04 :

- Using Scikit-learn to Train a Simple Classification Model
- .....

#### TP 05 :

- Implement a clustering algorithm on a Dataset
- Visualiser les clusters : Clustering non supervisé (K-means, DBSCAN).
- ....

#### TP 06 :

- Building a simple neural network with TensorFlow or PyTorch or keras
- Build a simple CNN to classify images (example: Dataset MINIST)
- ...

### Method of evaluation:

**exam 60% , CC=40%**

### Bibliography:

- Ganascia, J.Gabriel (2024): AI explained to humans. Paris, France- Edition le Seuil.

- English, Lise, Dilhac, Antione, Dratwa, Jim et al. (2023): Ethics at the heart of AI. Quebec Obvia.
- J.Robert (2024): Natural Language Processing (NLP): definition and principles – Datasciences. Link: <https://datascientest.com/introduction-au-nlp-natural-language-processing>
- What is natural language processing. Link: <https://aws.amazon.com/fr/what-is/nlp/>
- M.Journe: Elements of Discrete Mathematics – Ellipses
- F.Challet: Deep learning with Python – Eyrolles
- H.Bersini (2024): Artificial intelligence in practice with Python – Eyrolles
- B.Prieur (2024): Natural Language Processing with Python – Eyrolles
- V.Mathivet ( 2024) : Implementation in Python with Scikit-learn – Eyrolles
- G.Dubertret (2023): Introduction to cryptography with Python – Eyrolles
- S.Chazallet (2023): Python 3 – The fundamentals of language - Eyrolles
- H.Belhadeh, I.Djemal: NLP Method – Course of the University of Msila - Algeria

**Semester : 2**  
**Teaching unit: UET 1.2**  
**Subject: Compliance with the standards and rules of ethics and integrity**  
**VHS: 10:30 p.m. (Lecture: 1h30)**  
**Credit: 1**  
**Coefficient : 1**

### **Teaching objectives:**

To develop students' awareness of the respect of ethical principles and the rules that govern life at the university and in the world of work. Raise awareness of respect for and appreciation of intellectual property. Explain to them the risks of moral ills such as corruption and how to combat them, alert them to the ethical issues raised by new technologies and sustainable development.

### **Recommended prior knowledge:**

Ethics and deontology (the basics)

### **Content of the material:**

#### **A. Respect for the rules of ethics and integrity,**

**1. Reminder of the MESRS Charter of Ethics and Professional Conduct:** Integrity and Honesty. Academic freedom. Mutual respect. Requirement of scientific truth, Objectivity and critical spirit. Equity. Rights and obligations of the student, teacher, administrative and technical staff,

#### **2. Honest and responsible research**

- Respect for the principles of ethics in teaching and research
- Responsibilities in teamwork: Professional equality of treatment. Conduct against discrimination. The search for the general interest. Inappropriate conduct in the context of collective work
- Adopting responsible conduct and combating abuses: Adopting responsible conduct in research. Scientific fraud. Conduct against fraud. Plagiarism (definition of plagiarism, different forms of plagiarism, procedures to avoid unintentional plagiarism, plagiarism detection, sanctions against plagiarists, etc.). Falsification and fabrication of data.

#### **3. Ethics and deontology in the world of work:**

Legal confidentiality in business. Loyalty to the company. Corporate Accountability, Conflicts of Interest. Integrity (corruption in the workplace, its forms, consequences, methods of combating and sanctioning corruption)

#### **B- Intellectual property**

##### **I- Fundamentals of intellectual property**

- 1- Industrial property. Literary and artistic property.
- 2- Rules for citing references (books, scientific articles, communications in a congress, theses, dissertations, etc.)

##### **II- Copyright**

###### **1. Copyright in the digital environment**

Introduction. Copyright of databases, copyright of software. Specific case of free software.

## 2. Copyright in the Internet and Electronic Commerce

Domain name law. Intellectual property on the internet. E-commerce Site Law. Intellectual Property and Social Media.

## 3. Patent

Definition. Rights in a patent. Usefulness of a patent. Patentability . Patent application in Algeria and around the world.

### III- Protection and enhancement of intellectual property

How to protect intellectual property. Violation of rights and legal tool. Valuation of intellectual property. Protection of intellectual property in Algeria.

## C. Ethics, sustainable development and new technologies

Link between ethics and sustainable development, energy saving, bioethics and new technologies (artificial intelligence, scientific progress, humanoids, robots, drones.

### Method of evaluation:

Review: 100%

### Bibliographical references:

- [1]. *The World Intellectual Property Organization website* [www.wipo.int](http://www.wipo.int)
- [2]. *Charter of University Ethics and Professional Conduct*, [https://www.mesrs.dz/documents/12221/26200/Charte+fran\\_ais+d\\_f.pdf/50d6de61-aabd-4829-84b3-8302b790bdce](https://www.mesrs.dz/documents/12221/26200/Charte+fran_ais+d_f.pdf/50d6de61-aabd-4829-84b3-8302b790bdce)
- [3]. *Orders No. 933 of 28 July 2016 laying down the rules relating to the prevention and fight against plagiarism*
- [4]. *The ABCs of Copyright, United Nations Educational, Scientific and Cultural Organization (UNESCO)*
- [5]. *E. Prairat, De la déontologie enseignante. Paris, PUF, 2009.*
- [6]. *Racine L., Legault G. A., Bégin, L., Éthique et ingénierie, Montréal, McGraw Hill, 1991.*
- [7]. *Siroux, D., Déontologie: Dictionnaire d'éthique et de philosophie morale, Paris, Quadriège, 2004, p. 474-477.*
- [8]. *Medina Y., La déontologie, ce qui va changer dans l'entreprise, éditions d'Organisation, 2003.*
- [9]. *Didier Ch., Penser l'éthique des ingénieurs, Presses Universitaires de France, 2008.*
- [10]. *Gavarini L. and Ottavi D., Editorial. Professional Ethics in Training and Research, Research and Training, 52 | 2006, 5-11.*
- [11]. *Caré C., Morale, éthique, déontologie. Administration and Education, 2nd Quarter 2002, No. 94.*
- [12]. *Jacquet-Francillon, François. Concept: professional ethics. Le télémaque, May 2000, n° 17*
- [13]. *Carr, D. Professionalism and Ethics in Teaching. New York, NY Routledge. 2000.*
- [14]. *Galloux, J.C., Industrial Property Law. Dalloz 2003.*
- [15]. *Wagret F. and J-M., Patent of invention, trademarks and industrial property. PUF 2001*
- [16]. *Dekermadec, Y., Innovating through patents: a revolution with the internet. Insep 1999*
- [17]. *AEUTBM. The engineer at the heart of innovation. University of Technology Belfort-Montbéliard*
- [18]. *Fanny Rinck and Léda Mansour, Literacy in the Digital Age: Copying and Pasting Among Students, Université Grenoble 3 and Université Paris-Ouest Nanterre la Défense Nanterre, France*
- [19]. *Didier DUGUEST IEMN, Citing your sources, IAE Nantes 2008*
- [20]. *Similarity detection software: a solution to electronic plagiarism? Report of the Working Group on Electronic Plagiarism presented to the CREPUQ Subcommittee on Pedagogy and ICT*
- [21]. *Emanuela Chiriac, Monique Filiatrault and André Régimbald, A Student's Guide: Intellectual Integrity, Plagiarism, Cheating and Fraud... avoid them and, above all, how to cite your sources, 2014.*
- [22]. *Publication of the University of Montreal, Plagiarism Prevention Strategies, Integrity, Fraud and Plagiarism, 2010.*
- [23]. *Pierrick Malissard, Intellectual Property: Origin and Evolution, 2010.*

[24]. <http://www.app.asso.fr/>

[25]. <http://ressources.univ-rennes2.fr/propriete-intellectuelle/cours-2-54.html>

**V - Detailed programme by subject of the S3 semester**

**Semester : 3**

**Teaching unit: UEF 2.1.1**

**Material 1: Industrial programmable logic controllers**

**VHS: 45h00 (Lecture: 1h30, TD: 1h30)**

**Credits: 4**

**Coefficient: 2**

**Teaching objectives:**

This course allows the student to understand the hardware and software organization of APIs, to choose an API and associated components according to the desired application, and to use a programming language adapted to the API.

**Recommended prior knowledge:**

Combinatorial and sequential logic, Microprocessors, Microcontrollers, Sensors.

**Content of the material:**

**Chapter 1: Machine Automation**

**(4 weeks)**

1. Structural models
  - 1.1 Block diagram
  - 1.2 Process Diagrams
  - 1.3 Circuit diagrams
    - 1.3.1 Nomenclature and coding
  - 1.4 Functional Models
    - 1.4.1 Binary logic and Boolean algebra
    - 1.4.2 Combinatorial logic
    - 1.4.3 Sequential logic
    - 1.4.4 Synthesis of sequential systems

**Chapter 2: The GRAFCET (3 weeks)**

- 2.1. Introduction to Grafcet
- 2.2. The ladder language
- 2.3. Translating a grafcet into a ladder
- 2.4. Transcription of a specification in grafcet

**Chapter 3: Petri Nets(3 weeks)**

- 3.1 Basics
- 3.2 Retail RdP
- 3.3 Properties of RoPs
- 3.4 Markup Graph & Coverage Tree
- 3.5 Linear Algebra
- 3.6 Test your knowledge

**Chapter 4: Programmable Logic Controllers (4 weeks)**

- 4.1 Hardware – PLC Architecture and Ranges
- 4.2 THE CENTRAL UNIT
  - 4.2.1 Introduction
  - 4.2.2 CPU Software Functions
  - 4.2.3 The processor

- 4.2.4 Memory
- 4.2.5 The Operating Cycle
- 4.2.6 Operational safety
- 4.3 INDUSTRIAL COUPLERS
- 4.3.1 General
- 4.3.2 Input Couplers
- 4.3.3 Output Couplers
- 4.3.4 I/O Architecture
- 4.3.5 Smart Couplers
- 4.4 POWERING UP AN AUTOMATED SYSTEM
- 4.4.1 Power Supply
- 4.4.2 Pneumatic Power

**Evaluation method:**

Continuous assessment: 40%; Examination: 60%.

**Bibliographical references:**

- [1] .F. Baccelli, G. Cohen, G.J. Olsder, and J.-P. Quadrat, *Synchronization and linearity, an Algebra for Discrete Event Systems*, Wiley, 1992.
- [2] .C.G. Cassandras and S. Lafortune, *Introduction to Discrete Event Systems*, Kluwer Academic Publishers, 1999.
- [3] .C. G. Cassandras, *Discrete Event Systems: Modelling and Performance Analysis*, Aksen Associates Inc. Publishers, Homewood, IL and Boston, MA, 1993.
- [4] .G. DeMicheli, *Digital Design*, McGraw Hill, New York, 1993.
- [5] .H.R. Lewis and C.H. Papadimitriou, *Elements of the Theory of Computation*, Prentice Hall, Englewood Cliffs, 1981.
- [6] .René David and Hassan Alla, *Discrete Continuous and Hybrid Petri Nets*, Springer Verlag, 2005.
- [7] .Adepa - Afcet, *Le Grafcet*, Edition Cepadues, 2nd ed, 1995
- [8] .René David, Hassan Alla. *From Grafcet to Petri Networks*. Edition Hermès, 1992.
- [9] .J.C. Bossy, P. Brard, P. Faugère, C. Merlaud, *Le Grafcet: sa pratique et ses applications*, Educavivre, Ed. Casteilla, 1995.
- [10] . Simon Moreno, Edmond Peulot. *Le Grafcet: Design-Implementation in Programmable Logic Controllers*. Edition Casteilla, 2009.
- [11] . G. Michel. *APIs: Architecture and applications of programmable logic controllers*. Edition Dunod 1988.
- [12] . William Bolton. *Industrial programmable logic controllers*. Edition Dunod 2010.
- [13] . J.C. Humblot, *Industrial Programmable Automata*, Hermes Science Publications, 1993.
- [14] . M. Diaz, *Petri Nets: Fundamental Models*. *Traité IC2-Série Informatique et Systèmes d'Information*, Hermes Science, 2001.
- [15] . A. Choquet-Geniet, *Les réseaux de Pétri : Un outil de modélisation (Petri networks: A modelling tool)*, Dunod, 2006.
- [16] . Daniel Bouteille et al., *Les automatismes programmables*, Cepadues-Editions, 2nd edition, 1997.
- [17] . Henri Ney, *Eléments d'automatismes*, *Collection Electrotechnique et normalisation*, Edition Nathan, 1996.
- [18] . P. Borne, G. Dauphin-Tanguy, J.-P. Richard, F. Rotella, I. Zambettakis, *Automatic Analysis and Regulation of Industrial Processes, Volume 2 Numerical Regulation*, Technip Editions

**Semester : 3**  
**Teaching unit: UEF 2.1.1**  
**Material 2: Industrial Actuators**  
**VHS: 45h00 (Lecture: 1h30, TD: 1h30)**  
**Credits: 4**  
**Coefficient : 2**

**Teaching objectives:**

To give students the necessary notions on the most common actuators in industrial instrumentation.

**Recommended prior knowledge:**

Notions of power electronics, electrical engineering.

**Content of the material:**

**Chapter 1: Electric Actuators (3 weeks)**

- 1.1 Electric pre-actuators: The relay, The contactor, The disconnecter, The fuses, The thermal relay.
- 1.2 Electromechanical converters: Machine organization, Principle of operation, DC motor start, Power balance, DC machine reversibility, Motor power, Variable speed operation
- 1.3 Stepper motors: Permanent magnet motor, Variable reluctance motor, Hybrid motor

**Chapter 2: Pneumatic and hydraulic actuators (3 weeks)**

- 2.1 Pneumatic energy: Constitution of a pneumatic installation, Production of pneumatic energy, Physical principles.
- 2.2 Pneumatic Pre-Actuators: Function, Components of a Valve, Main Pneumatic Valves, Control Devices, Application: Pneumatic Press.
- 2.3 Pneumatic actuators: Cylinders, Vacuum generator or venturi.
- 2.4 Hydraulic actuators: Definition, Main types of cylinders, Sizing of cylinders, Applications.

**Chapter 3: Electrostatic Actuators**

**(2 weeks)**

**Chapter 4: Material Deformation Actuators(1 week)**

**Chapter 5: Ultrasonic actuators ( 1 week)**

**Chapter 6: Impact drives (1 week)**

**Chapter 7: Stick and slip actuators: the glue-slip effect (1 week)**

**Chapter 8: Smart Actuators (2 weeks)**

**Evaluation method:**

Continuous assessment: 40%; Examination: 60%.

**Bibliographical references:**

- [1] .Guy Clerc, Guy Grellet, *Electric Actuators, Models, Control, Eyrolles, 1999.*
- [2] .Gérard Lacroux, *Electric Actuators for Robotics and Servos, 1994.*
- [3] .Yves Granjon, *Automatique : Systèmes linéaires, nonlinéaires, temps continu, temps discret, représentation d'état, Dunod, 2010.*
- [4] J. Faisandier, *Hydrauliques et pneumatiques, Dunod, 1999.*
- [5] .R. Labonville, *Conception des circuits hydrauliques, une approche énergétique, Editions de l'Ecole Poly technique de Montréal, 1991.*
- [6] .P. Maye, *Electric Motors for Robotics, Dunod, 2000.*
- [7] .Michel Grout, Patrick Salaun, *Industrial Instrumentation, 3rd edition, Dunod, 2012.*
- [8] .Michel Pinard, *Control of electric motors, Dunod collection l'usine nouvelle 2004*
- [9] .M. Portelli, *La technologie d'hydraulique industrielle, cours et exercices résolus, Educactivres, Casteila, 2005.*
- [10] . [https://infoscience.epfl.ch/record/32233/files/EPFL\\_TH1756.pdf](https://infoscience.epfl.ch/record/32233/files/EPFL_TH1756.pdf)

[11]. <http://www.technologuepro.com/cours-genie-electrique/cours-27-capteurs-actionneurs-instrumentation/>

**Semester: 3**

**Teaching unit: UEF 1.1.1**

**Subject 3: Advanced Sensors and Measurement Systems**

**VHS: 10:30 pm (Lecture: 1h30, TD: )**

**Credits: 3**

**Coefficient: 1**

**Teaching objectives:**

Investigate the innovative functions of advanced sensors that have a positive impact on a system.

**Recommended prior knowledge:**

Electrical and electronic measurements, conventional sensors.

**Material content:**

**Chapter 1: Sensor Reminders**

**(01weeks)**

Passive and Active Sensors, Measurable Quantities, Sensor Classifications

**Chapter 2: Smart Sensors**

**(06 weeks)**

Definitions. Static and dynamic properties. Internal structure of a smart sensor: Packaging circuits, Data processor, Communication interface. Metrology of smart sensors: Calibration, Accuracy and validation of measurements, Remote commissioning, Self-diagnosis. Sensor networks

**Chapter 2: Applications of Smart Sensors (02 weeks)**

Manufacturing Application, Water Treatment Application, Continuous Process Application, Home Automation Application and Embedded Application.

**Chapter 3: New Advanced Sensor Technologies (03 weeks)**

Innovative features. Advanced micro-measurement sensors (strain gauges). Description of the components, types, and applications of advanced sensor systems (thermal, mechanical, magnetic, and chemical).

**Chapter 4: Advanced sensor for new industrial opportunities (Wireless sensor)**

**(01 weeks)**

Wireless Sensor Hardware Architecture, Applications, Wireless Protocols, Comparison Between Wireless Protocols.

**Chapter 5: Intelligent Measurement and Monitoring Techniques (01 weeks)**

Procedure for intelligent monitoring, intelligent sensors and intelligent monitoring, choice of sensor.

**Bibliographical references:**

1. Lin, Y.-L., Kyung, C.-M., Yasuura, H., Liu, Y., *Smart Sensors and Systems*
2. Ian R. Sintclair, *Sensors and transducers*, Newnes, 2001.
3. M. Bayart, B. Conrard, A. Chovin, M. Robert, *Intelligent Sensors and Actuators*, 2005.
4. Julian W. Gardner, Vijay K. Varadan, Osama O. Awadelkarim, *Microsensors, MEMS, and Smart Devices Hardcover*, 2001.
5. Randy Frank, *Understanding Smart Sensors*, 2nd ed. Edition, Artech House.
6. Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, *Smart Material Systems and MEMS: Design and Development Methodologies*.
7. *Smart Sensor Systems*, edited by Gerard C.M. Meijer, John Wiley & Sons, Ltd. ISBN: 978-0-470-86691-7

8. *Fiber Bragg gratings: fundamentals and applications in telecommunications and sensing*, A. Othonos, K. Kalli, Artech House, ISBN: 0890063443, 9780890063446

**Evaluation method:**

Continuous assessment: 40%; Examination: 60%.

**Semester: 3**

**Teaching unit: UEF 2.1.2**

**Material 4: Advanced Power Electronics**

**VHS: 45h00 (Lecture: 1h30, TD: 1h30)**

**Credits: 4**  
**Coefficient: 2**

**Teaching objectives:**

Master the operation of the main static converters, acquire the knowledge for a technical choice according to the field of application of a power converter.

**Recommended prior knowledge:**

Power electronics.

**Material content:**

1. AC-DC Converters
2. DC-AC Converters
3. Thyristors and controlled AC/DC conversion
4. Triacs and direct AC/AC conversion
5. Power transistors and DC/DC conversion
6. La Conversion DC/AC
7. Principles of synthesis of static converters
8. Losses and heat dissipation related to power components
9. Power integrated circuits and integrated regulators

**Evaluation method:**

Continuous assessment: 40%; Examination: 60%.

**Bibliographical references:**

9. *F. Mazda. Power Electronics Handbook: Components, Circuits and Application, 3rd Edition, Newnes, 1997.*
10. *C.W. Lander. Power Electronics, McGraw-Hill, 1981.*
11. *L. Lasne, Power Electronics: Courses, Case Studies and Corrected Exercises, Dunod, 2011.*
12. *J. Laroche, Power Electronics – Converters: Corrected Courses and Exercises, Dunod, 2005.*
13. *G. Séguier et al. Power Electronics: Corrected Courses and Exercises, 8th edition, Dunod, 2004.*
14. *D. Jacob, Power Electronics - Operating Principle, Sizing, Ellipses Marketing, 2008.*
15. *G. Séguier, L'électronique de pouvoir, les fonctions de bases et leurs principales applications, Tech et Doc.*
16. *H. Bühler, Power Electronics, Dunod*
17. *C.W. Lander, Power Electronics, McGraw-Hill, 1981*
18. *H. Buhler, Electronique de Régulation et de Command, Traité d'électricité.*
19. *F. Mazda, Power Electronics Handbook: Components, Circuits and Application, 3rd Edition, Newness, 1997.*
20. *R. Chauprade, Controls of alternating current motors (Power electronics), 1987.*
21. *R. Chauprade, Controls of DC motors (Power electronics), 1984.*

**Semester: 3**  
**Teaching unit: UEF 2.1.2**  
**Subject 5: Elements of digital control**  
**VHS: 45h00 (Lecture: 1h30, TD: 1h30)**  
**Credits: 4**  
**Coefficient: 2**

### **Teaching objectives:**

The objective of this course is to discover the different elements of numerical control used for the control of dynamic systems. Thus, learn the different components in a control chain: transmitter, sensor, actuator, correctors. To provide tools and methods to: analyze linear dynamical systems with discrete time, design numerical control elements and oriented the developed schemes towards their real-time implementation on real physical processes.

### **Recommended prior knowledge:**

- ✓ Analog control elements;
- ✓ Digital signal processing;
- ✓ Sampled linear servoing.

### **Content of the material:**

#### **Chapter 1. Reminder about analogue control (2 weeks)**

Modeling of physical systems: model of an RLC circuit, model of a mechanical system, model of a control valve. Model of an oven. Electrical-Mechanical Analogies and Symbolic Representation of Analog Regulation. Complex analog control schemes.

#### **Chapter 2. Analogue control elements (2 weeks)**

Elements of a control loop: Transmitter, regulator, positioner, servo motor, cylinders. Modes of action of regulators: On/off, proportional, integral and derivative (PID) action, hysteresis. Control strategies: Direct regulation, Cascading regulators, Split-range regulation, Feedforward regulation, Override regulation.

#### **Chapter 3. Digital control (4 weeks)**

Structure of the digital control: Control diagram, choice of discretization step, Converters (ADC and DAC), digital regulator (ECU). Objectives of the correction: Specifications, Analysis of the performance of the closed-loop system (stability, speed and accuracy). Industrial digital control elements: digital PID, microcontroller. Advantages and disadvantages of digital control elements: Example Comparisons between analog and digital IP.

#### **Chapter 4. Digital control elements (4 weeks)**

Standard digital control element: Transposition of analog correctors, Ziegler-Nichols PID, Digitized phase advance. Takahashi Digital P, PI, PID Regulators, Anti-Windup Circuit (Smith Predictor). Elements of numerical control with finite establishment time: absolute minimum, non-absolute minimum, with stack response, solution of the Diophantine equation.

#### **Chapter 5. Advanced numerical control elements (3 weeks)**

Numerical control diagram and specifications, Synthesis by the Zdan method, Digital RST controller, Linear quadratic controllers (LQ), Digital adaptive corrector, Choice of element and numerical correction method. Time and frequency analysis of the numerically controlled looped system.

**Method of evaluation:**

Continuous assessment: 40%; Examination: 60%.

**Bibliographical references :**

- [1] .P. Borne, G.D. Tanguv, J. P. Richard, F. Rotella, I. Zambetalcis, *Analysis and regulation of industrial processes - Numerical regulation, Volume 2, Editions Technip, 1993;*
- [2] .Robert L. Williams, Douglas A, Lawrence, *Linear State-Space Control Systems, Edition John Wiley & Sons, 2007 ;*
- [3] .Y. Granjon, *Linear, Nonlinear Systems, Continuous-Time, Discrete-Time, State Representation, 2nd Edition, Dunod, Paris, 2010;*
- [4] .R. Longchamp, *Numerical Control of Dynamic Systems, Presses Polytechniques et Universitaires Romandes, 1995;*
- [5] .D. Lequesne, *Régulation P.I.D: Analogique, numérique et floue, Edition Hermès, 2005;*
- [6] .G. F. Franklin, J. D. Powell, L. M. Workman, *Digital Control of Dynamic Systems, Addison-Wesley Series in Electrical and Computer Engineering: Control Engineering, 1990 ;*
- [7] .M. Retif, *Synthesis of a robust order: Sampled correctors, control by P.I.D., by state model and RST-Automatic polynomial, Ellipses Marketing, 2011;*
- [8] .E. Godoy, E. Ostertag, *Numerical Control of Systems: Frequency and Polynomial Approaches, Ellipses Marketing, 2004;*
- [9] .R. Longchamp, *Numerical Control of Dynamic Systems, Presses Polytechniques et Universitaires Romandes, 2006;*
- [10] . D. V. Bobál, J. Böhm, J. Fessel, J. Macháček, *Digital self-tuning controllers: Algorithm, implementation and application, Advanced Textbooks in control and signal processing, Springer-verlag London limited, 2005;*
- [11] . E. Gody, *Industrial Regulation: Modeling Tools, Control Methods and Architectures, 3rd Edition, Dunod, Paris, 2019;*

**Semester: 3**  
**Teaching unit: UEM 2.1**  
**Material 1: TP Programmable Logic Controllers**  
**VHS: 10:30 pm (TP: 1h30)**  
**Credits: 2**  
**Coefficient: 1**

### **Teaching objectives:**

At the end of this practical work, the student will be able to:

- Understand the relationship between the operational part (the system to be controlled) and the control part (the programmable logic controller) for an automated system.
- Carry out the wiring of the input/output interfaces of a PLC.
- Program a programmable logic controller to manage the actions provided for in the specifications in a sequential manner.

### **Recommended prior knowledge:**

- ✓ Programmable logic controllers course.

### **Material content:**

#### **TP 1. Grafcet modelling and simulation.**

**(2 weeks)**

Use a Grafcet simulation software (EDUGRAF, AUTOMGEN...), in order to understand the relationship between each step of the Grafcet and the action(s) to be commanded and the relationship between each transition and the state of the sensor(s) of the operative part.

#### **TP 2. Wiring the PLC with the operative part**

**(2 weeks)**

Wiring of the PLC power supply and wiring of the PLC I/O interfaces with the actuators and sensors of the operating part.

#### **TP 3. Introduction to PLC programming software (2 weeks)**

Introduction to programming blocks, functional blocks (Timer, Counter,...) and programming languages (Contact, List, Graph, ...)

#### **TP 4. Programming with the different languages of a PLC (4 weeks)**

Programming of the Grafcets of the automated systems (pedagogical models) available.

### **Evaluation method:**

Continuous assessment: 100%.

### **Bibliographical references:**

- [1] .Automation and control technology-SCE;
- [2] .[https://www.academia.edu/25781071/Automatisation\\_et\\_technique\\_des\\_commandes\\_SCE](https://www.academia.edu/25781071/Automatisation_et_technique_des_commandes_SCE)
- [3] .Wiring of PLC inputs and outputs;
- [4] .[https://www.eic2.ch/pdf/cablage\\_securite\\_ed905.pdf](https://www.eic2.ch/pdf/cablage_securite_ed905.pdf)
- [5] .Process automation, control technology, EDS;
- [6] .[https://www.festo-didactic.com/ov3/media/customers/1100/56845\\_2019\\_04\\_fr\\_extract\\_pa\\_eds\\_s.pdf](https://www.festo-didactic.com/ov3/media/customers/1100/56845_2019_04_fr_extract_pa_eds_s.pdf)  
Automate programmable S7-1200;
- [7] .[https://media.automation24.com/manual/fr/61777246\\_s71200\\_System\\_Manual\\_fr-FR\\_fr-FR.pdf](https://media.automation24.com/manual/fr/61777246_s71200_System_Manual_fr-FR_fr-FR.pdf)
- [8] .Training document for a complete solution ... - Siemens
- [9] .<https://www.automation.siemens.com/sce-static/learning-training-documents/classic/advanced-programming/b05-struct-prog-fr.pdf>

**Semester: 3**  
**Teaching unit: UEM 2.1**  
**Subject 2: TP Industrial Actuators / TP Digital Control**  
**VHS: 10:30 pm (TP: 1h30)**  
**Credits: 2**  
**Coefficient: 1**

**Teaching objectives:**

To enable students to exploit and master the theoretical concepts studied in class.

**Recommended prior knowledge:**

- ✓ Courses elements of digital regulation;
- ✓ Industrial actuators course;

**Content of the material:**

Teachers are asked to choose two to three practical exercises for each subject from the two lists of practical exercises presented below.

**TP Digital Control**

**TP1:** Modeling and analysis of sampled systems using Matlab-Simulink software.

**TP2:** Numerical regulation by PID of a dynamical system: by the methods of Ziegler-Nichols and Takahashi.

**TP3:** Analog and digital speed control of a DC motor (Phase Advance Corrector).

**TP4:** Digital temperature control (Battery response correction)

**TP5:** Numerical control of an inverted pendulum (Zdan Advanced Control Approach or RST).

**TP6:** Study of a digital servo of a flexible arm (performance comparisons between a PID and advanced control)

**TP Industrial Actuators**

**TP1:** Stepper motor.

**TP2:** DC and AC motor.

**TP3:** Implementation of a pneumatic system.

**TP4:** Hydraulic servo cylinder.

**TP5:** Adjustment valve.

**TP6:** Thermal Actuators.

**Method of evaluation:**

Continuous assessment: 100%.

**Bibliographical references :**

- [1].P. Borne, G.D. Tanguv, J. P. Richard, F. Rotella, I. Zambetalcis, *Analysis and regulation of industrial processes - Numerical regulation, Volume 2, Editions Technip, 1993;*
- [2].R. Longchamp, *Numerical Control of Dynamic Systems, Presses Polytechniques et Universitaires Romandes, 1995;*
- [3].D. Lequesne, *Régulation P.I.D: Analogue, numérique et floue, Edition Hermès, 2005;*
- [4].M. Retif, *Synthesis of a robust order: Sampled correctors, control by P.I.D., by state model and RST- Automatic polynomial, Ellipses Marketing, 2011;*
- [5].E. Gody, *Industrial Regulation: Modeling Tools, Control Methods and Architectures, 3rd Edition, Dunod, Paris, 2019;*

- [6] .G. Clerc, G. Grellet, *Electric-Actuators, Models, Control*, Eyrolles, 1999.
- [7] .G. Lacroux, *Electric Actuators for Robotics and Servos*, 1994.
- [8] .J. Faisandier, *Hydrauliques et pneumatiques*, Dunod, 1999.
- [9] .R. Labonville, *Conception des circuits hydrauliques, une approche énergétique*, Editions de l'Ecole Poly technique de Montréal, 1991.
- [10] . Michel Grout, Patrick Salaun, *Industrial Instrumentation*, 3rd edition, Dunod, 2012.

**Semester:3**  
**Teaching unit: UEM2.1**  
**Material3: TP Advanced Power Electronics**  
**VHS: 10:30 pm (TP: 1h30)**  
**Credits: 2**  
**Coefficient: 1**

**Teaching objectives:**

The aim is to understand the operation and characteristics of the different types of basic converters and their applications to machines.

**Recommended prior knowledge:**

Power electronics.

**Material content:**

TP1. AC-DC converter

TP2. DC-AC converter

TP3. AC-to-AC Converter

TP4. DC-DC converter

TP5....

**Evaluation method:**

Continuous Assessment: 100%

**Bibliographical references**

**Semester:3**  
**Teaching unit: UEM2.1**  
**Subject 4: Reliability and maintenance of electronic systems**  
**VHS: 45h00 (Cours: 1h30, TP: 1h30)**  
**Credits: 3**  
**Coefficient: 2**

### **Teaching objectives:**

He is interested in the basic concepts of maintenance, mainly in the study and analysis of reliability, which is a very important concept for the safe operation of electronic systems. The evaluation and improvement of reliability will allow a good control of all sources of failure as well as a reduction in maintenance costs by optimizing stocks and supply. Know the basic concepts of maintenance.

### **Recommended prior knowledge:**

- ✓ Basic notions of probability and statistics.
- ✓ Knowledge of enumeration methods, Combinatorial analysis: arrangement, permutation, combination

### **Material content:**

#### **Chapter 1: Key Maintenance Concepts. (3 weeks: Lectures & Tutorials)**

Maintenance, Corrective maintenance, Predictive maintenance, The different levels of maintenance, terotechnology, maintenance, reliability, maintainability, availability, breakdown, failure, repair, troubleshooting, diagnosis, concept of CMMS, Definition of some acronyms: MTTF, MTTR, MUT, MDT, MTBF

#### **Chapter 2: Basic Probability Model(3 weeks: Lectures & Tutorials)**

Probability: event, experiment. Algebra of events: commutativity of union and intersection, absorption, distribution of union and intersection, neutral element and complementation. The axioms. Probability theorems: total probability, conditional probability, Bayes' theorem. Application of probability in electronics.

#### **Chapter 3: Application of probability theorems to reliability (3 weeks: Lectures & Tutorials)**

Systems: serial system, parallel system, mixed system, series-parallel system with symmetrical configuration, parallel-serial system with symmetrical configuration, mixed system with non-symmetrical configuration. Application of Bayes' theorem on the different previous configurations.

#### **Chapter 4: Notions of failures (3 weeks: Lectures & Tutorials)**

Failure classification, Failure rate, MTBF calculation, Distribution function and failure probability density. Common laws of reliability: exponential distribution, Weibull's distribution, binomial distribution, Poisson distribution. Fault Shafts

#### **Chapter 5: Inventory Management in Maintenance (3 weeks: Lectures & Tutorials)**

Definition of maintenance stock, Responsibilities of the different phases of maintenance stock management, Catalogue of maintenance stock items, Codification, Maintenance stock management rules, The "maintenance stock" file.

**Practical work :**

**TP1: Introduction to Computer-Assisted Maintenance Management (CMMS).**

**TP2: Practical application with the GestoMaint tool (Maintenance workshop management for Windows)-CMMS.**

**TP3: Creation of a database under ACCESS.**

**TP4: Management of electronic systems by Fast Maint (8.0.1)-CMMS simulation.**

**TP5: Inventory management in maintenance: Study of an ERP**

**Evaluation method:**

Continuous assessment: 40 %; Review: 60 %.

**Bibliographical references:**

- [1] .A. Pollard, *Reliability and Forecasting Statistics*;
- [2] .D. Dacunha-Castelle, M. Duflo, *Probabilites et Statistiques, Tome 1, Masson, 1982*;
- [3] .M.R. Spiegel, *Probabilities and Statistics, Courses and Problems, Schaum Series, McGraw Hill, 1981*;
- [4] .Jean Heng, *Pratique de la maintenance préventive, Dunod, 2002*;
- [5] .Renaud Cuignet, *Management de la maintenance, Dunod, 2002*;
- [6] .F. Monchy, *Maintenance: Methods and Organization, Dunod, 2000*;
- [7] .J. M. Bleux, J. L. Fanchon, *Maintenance: Automated Production Systems, Collection Etapes, Nathan, 1997*;
- [8] .Zwingelstein G, *Diagnostic de défaillance, Hermès, Paris 1997*;
- [9] .Raymond Magnan, *Pratique de la maintenance industrielle, Dunod, 2003*;
- [10] . A.Bellaouar, S.Beleulmi, *Course Reliability, Maintainability and Availability (FMD),Constantin University1, 2014*;
- [11] . J.Ph. Gayon. *Inventory management: Course notes, exercises, projects and annals. Industrial Engineering, INP Grenoble, 2015.*
- [12] . <https://www.cogep.com/fr/gmao/>

**Semester: 3**

**Teaching unit: UET 2.1**

**Material 1: Reverse Engineering**

**VHS: 45h00 (Course: 1h30 and Workshop: 1h30)**

**Credits: 2**

**Coefficient: 2**

**Teaching objectives:**

- Understand the principles and objectives of Reverse Engineering (RE) in the field of science and technology (ST),
- To be introduced to the tools and methods of the ER in the specialty concerned.
- Understand the value and ethics of the principles of the RE in the design, manufacture and quality assurance of products,
- Encourage critical thinking, technical curiosity, reasoned reverse engineering and innovation,
- Learn how to analyze, document, and model an existing system without initial documentation.

**Targeted skills**

- Break down and analyze an existing system,
- Faithfully reproduce a technical diagram or a 3D model from an existing product,
- Apply diagnostic and simulation tools,
- Work in a group on an exploratory project,
- Identify the legal limits of reverse engineering

Adaptability to specialties in the field of Science and Technology :

- All specialties in the ST field are concerned according to
- Examples of tasks: Digital technical documentation, technology watch results, Technical project management, Collaboration around plans, Report analysis, Understanding of industrial processes, Production data monitoring, Reporting techniques, Prototyping, Testing)

**Prerequisites:**

- Fundamental knowledge in the specialty.

**Content of the material:**

**1. Introduction to Reverse Engineering**

- History, legal and ethical issues of the ER,
- Definitions and fields of application: Approaches (hardware, software, processes, etc.)
- Fields: maintenance, remanufacturing, cybersecurity, competitive intelligence

**2. General Methodology**

- Analysis of a "black box" system
- Functional decomposition
- Block diagrams, inputs/outputs, energy or information flows

**3. Reverse engineering hardware**

- Electronic boards: visual inspection, component identification

- Use of tools: multimeter, oscilloscope, logic analyzer
- Electronic schematic recognition
- Reconstruction of schematics in KiCad / Proteus

#### 4. Reverse engineering software

- Static analysis of binaries (e.g. .exe, .hex)
- Decompilation, disassembly (introduction to Ghidra, IDA Free, or Hopper)
- Observation of behaviors: sniffing, monitoring (e.g. Wireshark)
- Microcontrollers: flash memory reading, firmware extraction

#### 5. Mechanical reverse engineering

- 3D scanning: scanner, manual measurements
- Reproduction of CAD models from existing parts
- Software used: SolidWorks, Fusion360

#### 6. Security and intrusion detection

- Reverse engineering in cybersecurity: malware detection, vulnerabilities
- Software signing, ROE protections (obfuscation, encryption)

#### 7. Real-life case studies

- Scan an outdated or unknown product (mouse, power supply, Bluetooth module, etc.)
- Example of reverse engineering of a mechanical part or simple system (fan, housing)

#### Examples of practical work (basic the 4 Geniuses)

- **Electrical Engineering:**

- Reverse engineering of an electronic module without a schematic
- Example: Bluetooth module, timer relay
- Objectives: to identify how it works, to draw the diagram, to propose an improved variant.
- Identification of components (ICs, transistors, resistors, etc.).
- Use of tools: multimeter, oscilloscope, logic analyzer.
- Reading and extracting firmware from a microcontroller.
- Introduction to the detection of electronic counterfeits.

- **Mechanical Engineering:**

- Reverse engineering a simple mechanism
- Examples: hand pump, torque wrench, mini-press, etc.
- Mechanical dismantling of a system (pump, gear, cylinder, etc.).
- Measurements and reconstruction of plans or 3D models with CAD software (SolidWorks, Fusion360).
- Identification of materials and manufacturing methods.
- Functional simulation from the recreated model.

- **Civil Engineering:**

- Analysis of existing structures without plans (walls, slabs, structures, etc.).
- Examples: metal stairs, window sills, formwork)
- Study and reverse engineering of an existing structural element
- Identification of materials, assemblies and constraints.
- Modeling of the structure via Revit, AutoCAD or SketchUp.
- Rehabilitation study or reproduction of old structural elements.

- **Process Engineering:**

- Reverse engineering a laboratory module
- Examples: instruments, distillation, filtration, heat exchanger, simple reactors, etc.
- Analysis of existing industrial systems (distillation column, heat exchanger, reactor, etc.).
- Reconstruction of PFD and PID diagrams from the observation of an installation.
- Identification of sensors, actuators, control devices.
- Study of material/energy flow in a process.

**Method of evaluation:**

- TP techniques
- Mini-project of reverse engineering (report + defense)
- Final exam (MCQ + case study)
  
- Exam: 60% and CC TP: 40%

**Bibliographical references:**

- Reverse Engineering for Beginners – Dennis Yurichev (free online)
- The IDA Pro Book – Chris Eagle (software)
- Practical Reverse Engineering – Bruce Dang
- Documentation :
  - <https://ghidra-sre.org>
  - <https://www.kicad.org>
  - <https://www.autodesk.com/products/fusion-360>

**Semester : 3**  
**Teaching unit: UET2.1**  
**Subject: Literature research and memory design**  
**VHS: 10:30 p.m. (Lecture: 1h30)**  
**Credit: 1**  
**Coefficient : 1**

**Teaching objectives:**

Give the student the necessary tools to look for useful information in order to better use it in his or her end-of-studies project. Help them go through the different steps leading to the writing of a scientific document. To show them the importance of communication and to teach them to present the work done in a rigorous and educational way.

**Recommended prior knowledge:**

Methodology of writing, Methodology of presentation.

**Material content:**

**Part I-: Documentary research:**

**Chapter I-1: Definition of the Subject (02 weeks)**

- Subject Title
- List of keywords relevant to the topic
- Gather basic information (acquisition of specialized vocabulary, meaning of terms, linguistic definition)
- The information sought
- Take stock of your knowledge in the field

**Chapter I-2: Select sources of information (02 weeks)**

- Type of documents (Books, Theses, Dissertations, Periodical Articles, Conference Proceedings, Audiovisual Documents, etc.)
- Type of resources (Libraries, Internet, etc.)
- Assess the quality and relevance of information sources

**Chapter I-3: Locate documents (01 Week)**

- Research techniques
- Search operators

**Chapter I-4: Processing information (02 weeks)**

- Work organization
- The initial questions
- Summary of the selected documents
- Links between different parties
- Final plan of the literature search

**Chapter I-5: Presentation of the bibliography (01 Week)**

- The systems of presenting a bibliography (the Harvard system, the Vancouver system, the mixed system, etc.)
- Presentation of documents.
- Citation of sources

## Part II: Memory Design

### Chapter II-1: Outline and stages of the thesis (02 weeks)

- Identifying and Defining the Subject (Summary)
- Problem and objectives of the dissertation
- Other useful sections (Acknowledgements, Table of Abbreviations, etc.)
- The introduction (*The writing of the introduction last*)
- State of the specialized literature
- Formulating the hypotheses
- Methodology
- Results
- Discussion
- Recommendations
- Conclusion and outlook
- The Table of Contents
- Bibliography
- Appendices

### Chapter II-2: Writing techniques and standards (02 weeks)

- Formatting. Numbering of chapters, figures and tables.
- The cover page
- Typography and punctuation
- The editorial staff. Scientific language: style, grammar, syntax.
- Spelling. Improved general language proficiency in comprehension and expression.
- Backup, secure, archive your data.

### Chapter II-3: Workshop: Critical study of a manuscript (01 Week)

### Chapter II-4: Oral presentations and defenses (01 Week)

- How to Present a Poster
- How to present an oral communication.
- Defense of a thesis

### Chapter II-5: How to Avoid Plagiarism ? (01 Week)

- (Formulas, phrases, illustrations, graphs, data, statistics,...)
- The quote
  - Paraphrasing
  - Indicate the complete bibliographic reference

#### Method of evaluation:

Review: 100%

#### Bibliographical references:

1. M. Griselin et al., *Guide de la communication écrit*, 2nd edition, Dunod, 1999.
2. J.L. Lebrun, *Guide pratique de rédaction scientifique: comment écrire pour le lecteur scientifique international*, Les Ulis, EDP Sciences, 2007.
3. A.Mallender Tanner, *ABC de la rédaction technique: modes d'emploi, instructions d'utilisation, aides en ligne*, Dunod, 2002.
4. M. Greuter, *Bien rédaction son mémoire ou son rapport de stage*, L'Etudiant, 2007.
5. Mr. Boeglin, *reading and writing at university. From the chaos of ideas to the structured text*. L'Etudiant, 2005.
6. M. Beaud, *l'art de la thèse*, Editions Casbah, 1999.
7. M. Beaud, *l'art de la thèse*, La découverte, 2003.
8. M. Kalika, *Le mémoire de Master*, Dunod, 2005.

## **Proposal of some discovery materials**

**Semester:**  
**Teaching unit: UED**  
**Subject1: Optoelectronics**  
**VHS: 10:30 pm (Lecture: 1h30)**  
**Credits: 1**  
**Coefficient: 1**

**Teaching objectives:**

Introduce the student to the main optoelectronic components, their characteristics, their operating principle and the areas of use.

**Recommended prior knowledge:**

Fundamental Electronics, Optoelectronic Devices.

**Material content:**

**Chapter 1: Elements of Photometry**

Optical sources (primary, secondary), Luminous flux, Solid angle, light intensity, luminance and illuminance of an optical source. Spectral quantities. Energetic and visual photometry. Color temperature. Lambertian Spring, ...

**Chapter 2: Photoemitters**

Technologies and features, Polar pattern pattern, ...

- La source LED
- The PIN photodiode
- The Laser diode, ....

**Chapter 3: Photoreceptors**

Photodiode, Phototransistor, Photovoltaic Cells, CCD

**Chapter 4: Application examples**

Motion detector (open-end opto-coupler), Opto-coupler for galvanic isolation, Luminescence detector, Contrast detector, Color detector, Photovoltaic generator, ...

**Chapter 5: Optical Fibers**

Reminders on refraction. The different types of optical fibers (Technologies and characteristics). Principles of light propagation in an optical fiber. Dispersions, Losses and Attenuations in an Optical Fiber

**Evaluation method:**

Review: 100%.

**Bibliographical references:**

1. P. Bhattacharya, *Semiconductor optoelectronic devices*, Prentice Hall 1997.
2. E. Rosencher, *Optoelectronics*, 2nd edition, Dunod, 2002.
3. R. Maciejko, *Optoelectronics*, Presses internationales Polytechnique, 2002.
4. K. Booth, *The essence of optoelectronics*, Prentice Hall 1998.
5. J. Wilson, *Optoelectronics – an introduction*, 3th ed., Prentice-Hall 1998.
6. J. Singh, *Semiconductor optoelectronics*, McGraw Hill, Inc., 1995.
7. D. Decoster, *Photoelectronic Detectors*, Lavoisier, 2002

**Semester:1**  
**Teaching unit: UED**  
**Subject2: Autonomous energy systems**  
**VHS: 10:30 pm (Lecture: 1h30)**  
**Credits: 1**  
**Coefficient: 1**

**Teaching objectives:**

To arouse the student's interest in renewable energies in general and in energy systems exploiting solar or wind energy in particular. To help the student acquire a certain skill in the sizing of a wind or photovoltaic installation.

**Recommended prior knowledge:**

General knowledge

**Material content:**

**Chapter 1: Electrical energy production devices,**

Notions on energy transformations (mechanical, thermal, hydraulic, etc.), history (Volta, Oersted, Faraday, etc.), the alternator, the dynamo, the methods of producing electrical energy (hydraulic power plant, thermal power plants). Non-renewable energy sources (fossil and nuclear). Renewable energy sources.

**Chapter 2: Wind Energy**

History, principle and structure, Characteristics and sizing, Map of the wind farm in Algeria, Wind farms and power, Standards, Advantages and disadvantages. Example of a wind power installation.

**Chapter 3: Hybrid Systems**

Hybrid Systems (Tidal turbine, Principle of operation of the tidal turbine, The different types of tidal turbines and the operators,...)

**Chapter 4: Photovoltaic solar energy**

Principle of a photovoltaic installation, the solar deposit in Algeria, Photovoltaic cell technologies, Photovoltaic modules, MPPT, Photovoltaic characteristics and connectors, Standards. The inverter (role, principle, characteristics and efficiency). Example of a photovoltaic installation.

**Chapter 5: Other Renewable Energy Sources**

Renewable energy families (solar energy, wind energy, hydropower, biomass, geothermal energy). The different renewable energies in the world. Cost-effectiveness.

**Evaluation method:**

Review: 100%.

**Bibliographical references:**

1. J. Vernier, *Renewable Energies*, PUF edition, 2012
2. E. Riolet, *Le mini-éolienne*, Eyrolles edition, 2010
3. A. Labouret and M. Viloz, *Photovoltaic Solar Energy*, Editions du Moniteur 2009
4. B. Fox, *Wind Electric Energy: Production, Forecasting and Grid Integration*, Technical and Engineering Collection, Dunod/L'Usine Nouvelle 2015 (2nd edition)
5. A. Damien, *Biomass Energy: Definitions, Resources and Modes of Transformation*, Technical and Engineering Collection, Dunod/L'Usine Nouvelle 2013 (2nd edition)

6. A. Labouret, M. Viloz, *Photovoltaic installations: Design and sizing of installations connected to the grid*, *Technical and Engineering Collection*, Dunod/Le Moniteur 2012 (5th edition)
7. <http://www.cder.dz/spip.php?article1442>

**Semester****Discovery Teaching Unit: UED****Subject 3: Electroacoustics and vibration analyses****VHS: 10:30 pm (Lecture: 1h30)****Credits: 1****Coefficient: 1****Teaching objectives:**

Acquire notions of acoustics and electroacoustics (noise measurements and analyses, sound recording and recording, electroacoustic chain, electro-mechanical-acoustic analogy). Application of Signal Processing to the monitoring of rotating machinery by vibration analysis.

**Recommended prior knowledge:**

Basic notions in physics (waves and vibrations), Electronics, Electrical Engineering and Signal Processing.

**Material content:****Chapter 1: Notions of acoustics****(4 weeks)**

Definition of an acoustic wave, sound pressure, sound velocity, acoustic acceleration and acoustic impedance; Production and modes of propagation of acoustic waves;  
General equation of propagation in terms of sound pressure and solutions: plane wave and spherical wave,  
Reflection and Refraction of Acoustic Waves,  
Acoustic levels, frequency bands for noise and vibration analysis,  
Auditory Perception, Iso-sonic Curves and Weighting Filters

**Chapter 2: Electro-acoustics****(5 weeks)**

Electroacoustic chain: sound source, condenser microphone, power amplifier, loudspeaker (electrodynamical),  
Sound recording and recording on different media,  
Noise measurements and analysis: description and operation of a sound level meter, microphone calibration, noise pollution assessment.  
Automatic audiometry  
Electro-mechanical-acoustic analogy

**Chapter 3 Vibration measurements and analyses****(6 weeks)**

Vibration, origins of vibrations, different types of vibrations (free, forced, resonance, self-excited),  
Vibrational signals: harmonic, complex periodic, random, transient, temporal and frequency representations,  
Application of signal processing to vibration analysis: notion of Spectrum, Auto-correlation and Cepstre,  
Rotating machinery maintenance strategies and monitoring parameters,  
Vibration measurement chain,  
Exploitation of measurement results. (diagnosis and detection of faults, etc.)

**Evaluation method:**

Review: 100%.

**Bibliographical references:**

1. J. Jouhaneau, *Elementary notions of acoustics, electroacoustics.*
2. Michel Bruneau, *Manual of Fundamental Acoustics*
3. Mario Rossi, *Electroacoustics, EPFL, 1979.*

4. *Graham Kelly, Mechanical Vibrations: Theory and Applications.*
5. *M., Digital Processing of Signals, Presses Polytechniques et Universitaires Romandes (PPUR).*
6. *Vibration analysis of rotating machines, Techniques de l'Ingénieur.*

**Semester :**  
**Teaching unit: UED**  
**Subject 4: Electromagnetic compatibility**  
**VHS: 10:30 p.m. (Lecture: 1h30)**  
**Credit: 1**  
**Coefficient : 1**

**Teaching objectives:**

To apply the general laws of electromagnetism to the problems of electromagnetic pollution of the environment and its effect on electronic systems. Acquire a global approach to research the potential causes of disturbance in a given environment. Choose an optimal protection technique.

**Recommended prior knowledge:**

Basics in mathematics, statistics and signal processing.

**Content of the material:**

**Chapter 1: Introduction to Electromagnetic Compatibility (EMC)**

Regulatory Bodies, Overview, Examples of Standards, Terminology Used.

**Chapter 2: Sources of Disturbance**

Classification according to W. Duff, Permanent/Intermittent Sources, Impulse Sources (i-electric arcs, lightning, ESD discharges, ii-electrical contacts and inductive charge, iii-electrostatic discharge).

**Chapter 3: Study of couplings**

Common Impedance Coupling, Capacitive Coupling, Inductive Coupling, Electromagnetic Radiation Coupling

**Chapter 4: EMC protection techniques**

Arrangement of components and wiring, shielding, filtering, surge protection.

**Chapter 5: Printed Circuit Boards and Integrated Circuits**

Emission Sources on a Circuit, Parameters of Some Logic Series, Static and Dynamic Noise Margins of Logic Series, Transition Currents – "Groundbounce", Inductance of Via Holes, Placement of Decoupling Capacitors, Single or Double-Sided Circuits, Single/Double-Sided Power Supplies, Multilayer Circuits, Traces, Transmission Lines, Characteristic Impedances, Line Matching Circuits.

**Chapter 6: Methods of investigation**

Standardized tests, Electrostatic discharge immunity tests, Conducted disturbance immunity tests, Voltage dip immunity tests, Short cuts, Radiation disturbance immunity tests, Magnetic field immunity tests, Measurement of emitted conducted disturbances, Measurement of radiated conducted disturbances.

**Method of evaluation:**

Review: 100%

**Bibliographical references:**

1. T. Williams, *Electromagnetic Compatibility from Design to Approval*.
2. Guy Gérard Champiot, *Electrical and electromagnetic disturbances*.
3. J.L. Cocquerelle, *EMC and power electronics*.
4. A. Charoy, *Parasites and Disturbances of Electronics: Grounds, Grounds, Wiring*.



**Semester :**

**Teaching unit: UED**

**Subject 5: Industrial instrumentation and measurements**

**VHS: 10:30 p.m. (Lecture: 1h30)**

**Credit: 1**

**Coefficient : 1**

**Teaching objectives:**

Introduce the student to industrial measurement techniques. Familiarize him with industrial measurement systems and introduce him to the problems of noise and interference in industrial instrumentation.

**Recommended prior knowledge:**

Instrumentation electronics, sensors, electrical and electronic measurements.

**Content of the material:**

**Chapter 1: Concepts of industrial measurements (2 weeks)**

Role of instruments, Symbolization and diagrams, Characteristics of a measuring device (Accuracy, resolution, response time, measurement range, linearity, physical quantity, ...), Voltage generators (0-10V), Current generators (0-20 mA and 4-20 mA). Connections (wired with 2, 3 and 4 wire contact, without wires, ...), static measurements and dynamic measurements.

**Chapter 2: Digital Acquisition of Analog Signals (Reminders) (2 weeks)**

Principles of an analog and digital measurement chain, Blocker sampler, conditioning, Analog-to-digital conversion (ADC), examples of ADCs, Accuracy and resolution of an ADC. Main functions of electronics in instrumentation (filtering, amplification, pulse generator, etc.)

**Chapter 3: Examples of systems industrial measurement systems (6 weeks)**

Introduction, classic equipment (voltmeter, clamp meters, megohmmeter, ...), Thermometry (with and without contacts, connection techniques, tolerances, ...), Manometry (general principles, different types, failures and anomalies...), Flowmetry (principles and examples, square root extractor, density-compensated flowmeter, flowmetry errors), Tachymetry (principle and equipment), Hygrometry (principle and equipment), Viscosity measurement (principle and equipment), Density and density measurement (densimetry), pH measurement (pH meter), Chromatography (principle and equipment), Conductivity measurement (principle and equipment), Spectroscopic analysis techniques (principle and equipment), ...

**Chapter 4: Noise and Interference in Electronic Instrumentation (2 weeks)**

Introduction, Origins of Noise in Electronic Circuits, Examples of Noise (Thermal, 1/f...), Noise Models in Amplification, Interference, Sources of Coherent Interference, Reduction of the Effects of Interference in Instrumentation

**Chapter 5: Measurement Networks and Instrumentation Buses (3 weeks)**

Introduction to instrumentation buses (principle, examples, protocols and standards), Link testers, frame analyzers, protocol analyzers, measurements by the HART protocol for Highway Addressable Remote Transducer (basic concepts, examples, maintenance via HART)

**Method of evaluation:**

Review: 100%

**Bibliographical references:**

1. G. Asch, *Sensors in Industrial Instrumentation*, Dunod, 2010.
2. P. Dassonville, *Les Capteurs : Exercices et problèmes correctes*, Dunod, 2005.
3. A. Migeon, *Applications industrielles des capteurs*, Hermès Science Publications, 1997.

4. *M. Cerr, Industrial Instrumentation, Volumes 1 and 2, Edition Tech and Doc.*
5. *F. Cottet, Signal Processing and Data Acquisition: Courses and Exercises, Dunod, 1999.*
6. *G. Asch et al., Data Acquisition, 3rd edition, Dunod, 2011.*
7. *J. G. Webster, Measurement, Instrumentation and Sensors Handbook, Taylor & Francis Ltd.*

**Semester :**

**Teaching unit: UED**

**Subject 6: Industrial safety**

**VHS: 10:30 p.m. (Lecture: 1h30)**

**Credit: 1**

**Coefficient : 1**

**Teaching objectives:**

Raise awareness of safety and the environment among staff. Assess and treat occupational risks.

**Recommended prior knowledge:**

Basic notions in chemistry and electrical engineering.

**Content of the material:**

**Chapter 1: Risk control elements**

Risk Concepts, The Different Areas of Safety, Safety Results in Industry, Safety Success Factors in Safety.

**Chapter 2: Approach applied in process industries**

Failure Mode, Effects and Criticality Analysis (FMEA), Feedback on Risk Management in Process Industries, Safety Management System (SMS), ISO 9000 Quality Standards - Version 2000

**Chapter 3: Chemical Hazards (Identification, Assessment, Control)**

Toxic products, Heat-sensitive products, Dangerous chemical reactions.

**Chapter 4: Safety of electrical installations:**

Electrical risks, Nature of electrical accidents and dangers of electric current, Protective measures, Safety measures against the indirect effects of electric current, Verification and control of installations.

**Chapter 5: Safety of Work Equipment and Pressure Vessels**

Technical regulations and standards, Inspection of steam and gas pressure vessels, Inspection of rotating machinery and thermal equipment, Inspection of piping and loading stations.

**Method of evaluation:**

Review: 100%

**Bibliographical references:**

1. L.G. Hewitson, *Guide to the Protection of Electrical Equipment*, Dunod, 2007.
2. P. Levalois, D. Gauvin, *Bilan des normes et recommandations d'exposition aux champs électromagnétiques*, 1996.
3. P. Dyevre, P. Merelan, *Effects on health of occupational exposure to ultraviolet radiation*, 1994.
4. Villemeur, *Sûreté de fonctionnement des systèmes industriels*, Dunod, 1988.
5. A. Lannoy. *Risk management and operational safety*. Publishers: Tec and Doc
6. E. Niel, E. Craye, *Maîtrise des risques de fonctionnement des systèmes de production*, Hermès, 2005.
7. A. Leroy, *Dictionnaire d'analyse et de gestion des risques*, Hermès, 2005.
8. T. Tanzy, *Risk Engineering*, Hermès, 2005.

**Semester :**  
**Teaching unit: UED**  
**Subject 7: Robotics**  
**VHS: 10:30 p.m. (Lecture: 1h30)**  
**Credit: 1**  
**Coefficient : 1**

**Teaching objectives:**

To introduce the student to the fundamental aspects of robotics and to recent developments in the field of industrial robotics.

**Recommended prior knowledge:**

None.

**Content of the material:**

**Chapter 1: General**

Definitions, Constituents of a robot, Classification of robots, Characteristics of a robot, Generations of robots, Programming of robots.

**Chapter 2: Degree of Freedom - Architecture**

Positioning of a solid in space, Liaison, Mechanisms, Morphology of robots, manipulators

**Chapter 3: Geometric Model of a Simple Chain Robot**

Need for a Model, Operational Coordinates, Translation and Rotation, Homogeneous Transformation Matrices, Obtaining the Geometric Model, Modified Denavit-Hartenberg Parameters, Inversion of the Geometric Model - Paul's Method, Multiple Solutions - Workspace - Aspects

**Chapter 4: Simplification Technique**

Speed and acceleration of robots, Jacobean matrix and its usefulness, Definition of equations in direct and inverse, Meaning of singularities.

**Method of evaluation:**

Review: 100%

**Bibliographical references:**

1. H. Asada, J.J.E. Slotine, *Robot Analysis and Control, a Wiley Interscience Publication, 1986.*
2. J.J. Craig, *Introduction to Robotics, Mechanics and Control, Addison-Wesley, 1989.*

**Semester :**  
**Teaching unit: UED**  
**Subject 8: Adjustment of Electric Drives**  
**VHS: 45h (Lecture: 3h00)**  
**Credit: 2**  
**Coefficient : 2**

**Teaching objectives:**

Introduce students to the adjustment of electrical drives, namely: Variable speed drives, or "servo drives" which require permanent control of the movement.

**Recommended prior knowledge:**

Basic knowledge of electrical engineering and electricity as well as automatic control.

**Content of the material:**

**Chapter 1: Introduction to Tuned Workouts**

- 1.1 Definition of Tuned Drives
- 1.2 Training users
- 1.3 Course Objectives
- 1.4 Applications of drives in the machinery industry

**Chapter 2: Drive with DC machine**

- 2.1 Introduction
- 2.2 Mathematical Modeling
  - 2.2.1 Recall: DC Motor Construction and Operation
  - 2.2.2 Characteristic equations
  - 2.2.3 Block diagram
  - 2.2.4 DC Machine Electrical Model
  - 2.2.5 Mechanical and Electrical Time Constants
  - 2.2.6 Torque-speed characteristic of the steady-state separated excitation machine
- 2.3 DC Drive Power
  - 2.3.1 Operation
  - 2.3.2 Static Feature
  - 2.3.3 Pulse Width Modulation (PWM) Current Drive Control
- 2.4 Energy Recovery
- 2.5 Current Regulation
  - 2.5.1 Analog PI Type Linear Regulator
- 2.6 Speed Control
  - 2.6.1 Structure of the cruise control system
  - 2.6.2 Modelling of the system to be adjusted
  - 2.6.3 Choice and Principle of Adjustment of Cruise Control
  - 2.6.4 Regulator Summary for Nominal Magnetization

**Chapter 3: Drive with self-switched synchronous machine**

- 3.1 Synchronous Machine Working Principle
- 3.2 Getting Started
- 3.3 Clarification on terminology: brushless DC and brushless AC motors
  - 3.3.1 Introduction
  - 3.3.2 Collectorless DC Motor
  - 3.3.3 Structure of the DC motor without collector
  - 3.3.4 Torque Control
  - 3.3.5 Magnetic distributions of the stator winding and permanent magnet
  - 3.3.6 Conclusion on the DC brushless machine
- 3.4 Mathematical Modeling of the Self-Switched Synchronous Machine ("AC Brushless")

- 3.4.1 Voltage Equations
- 3.4.2 Electromagnetic Torque
- 3.4.3 Phase Shift Between Current and EMF
- 3.5 Frequency Converter Power Supply
- 3.6 A first control strategy: the scalar control of the auto-switched synchronous machine
- 3.6.1 Measurement of the angular position
- 3.6.2 Current Servo Control
- 3.7 Self-Switched Synchronous Machine Vector Control

#### **Chapter 4: Training with an asynchronous machine**

- 4.1 General information about the asynchronous machine
  - 4.1.1 Constitution
  - 4.1.2 Principle of operation
- 4.2 Mathematical Steady-State Sinusoidal Modelling
  - 4.2.1 Equivalent Scheme of a Statoric Phase
  - 4.2.2 Electromagnetic torque in the permanent sinusoidal regime
- 4.3 Asynchronous Machine Scalar Control
  - 4.3.1 Constant air gap control
  - 4.3.2 Field loss regime
- 4.4 Asynchronous Machine Vector Control
  - 4.4.1 Equations of the asynchronous machine in the stator frame of reference
  - 4.4.2 Electromagnetic Torque
  - 4.4.3 Equations of the asynchronous machine in the frame of reference rotating at synchronous speed
  - 4.4.4 Orientation of the Axis System (Rotating) with Respect to the Rotor Flow
  - 4.4.5 Voltage-Current Transfer Functions

#### **Method of evaluation:**

Review: 100%

#### **Bibliographical references:**

1. Jean Bonal, Guy Séguier, *Entraînements électriques à vitesse variable, Tome 1, collection Schneider 1997.*
2. Jean Bonal, Guy Séguier, *Entraînements électriques à vitesse variable, Tome 2, collection Schneider 1998.*
3. Jean Bonal, Guy Séguier, *Entraînements électriques à vitesse variable, Tome 3, collection Schneider 1998.*
4. Michel Pinard. *Electronic control of electric motors, Dunod, 2004.*
5. Loron Luc. *Command of electrical systems, Lavoisier, 2000.*
6. J.-P. Caron, J.P. Hautier, *Modeling and Control of the Asynchronous Machine, Technip, 1995.*
7. G. Grellet, G. Clerc, *Electric-Actuators, Principles, Models, Controls, Eyrolles, 1996.*
8. J. Lesenne, F. Notelet, G. Séguier, *Introduction à l'électrotechnique approfondie, Technique et Documentation, 1981.*
9. J. CARON, J. HAUTIER, *MODELING AND CONTROL OF THE ASYNCHRONOUS MACHINE, TECHNIP EDITION, PARIS, FRANCE, 1995.*
10. R. Chauprade. *Controls of alternating current motors (Power electronics), 1987.*
11. R. Chauprade. *Direct Current Motor Controls (Power Electronics), 1984.*

**Semester :**  
**Teaching unit: UED**  
**Material 9: Bio instrumentation and biosensors**  
**VHS: 10:30 p.m. (Lecture: 1h30)**  
**Credit: 1**  
**Coefficient : 1**

**Teaching objectives:**

This course is designed to familiarize yourself with devices capable of collecting physiological and biological signals.

**Recommended prior knowledge:**

Fundamental transduction systems, Fundamental electronics, General chemistry.

**Content of the material:**

1. Origin of the biological signal
2. Noise in biological systems
3. Electrochemical electrode, Nerst's equation, Nickolskii
4. Ion and amperometric sensors
5. ECG, EMG, EEG recording
6. Recording the breathing signal
7. Recording the blood flow signal
8. Enzyme Bio Receptor, Biosensors
9. Biomedical and environmental application

**Method of evaluation:**

Review: 100%

**Bibliographical references:**

1. *Tran Minh Canh, Biosensors, Elsevier-Masson, 1991*
2. *G. Broun and C. Moreau, Les équipements biomédicales à l'hôpital et au laboratoire, Maloine, 1998.*
3. *R. Normann, Principles of Bioinstrumentation, Wiley, 1988.*
4. *T. Thomas, D.A. Corlis, J. Bailey, The Psychophysical Measurement of Visual Function, Butterworth-Heinemann 2003.*

**Semester :**

**Teaching unit: UED**

**Subject 10: Methods and tools for non-destructive testing**

**VHS: 10:30 p.m. (Lecture: 1h30)**

**Credit: 1**

**Coefficient : 1**

**Teaching objectives:**

This course is intended to help you choose non-destructive testing (NDT) methods and techniques for static and dynamic industrial equipment. It allows students to become familiar with this type of advanced testing.

**Recommended prior knowledge:**

Physics, electronics, sensors, measuring devices, automation.

**Content of the material:**

**Chapter 1: Reminders of the principles of condition-based maintenance**

Monitoring parameters, organization of condition monitoring.

**Chapter 2: Non-destructive testing (NDT) of static equipment:**

Adopt an NDT approach, Design pressurized metal capacities, Identify degradation risks, Prepare NDT, Apply regulations, Choose NDT methods and tools.

**Chapter 3: Dynamic Equipment Controls**

Vibration monitoring of rotating machinery, Establishing a budget for the acquisition of vibration monitoring means, *Oil* analyses

**Chapter 4: Expert Systems**

**Method of evaluation:**

Review: 100%

**Bibliographical references:**

1. Jean Claude Francastel, Ingénierie de la maintenance de la conception à l'exploitation d'un bien, Edition Dunod, 2007.
2. Nicolas Liebeaux, Modeling of Electromagnetic Sensors: Application to Non-Destructive Testing by Eddy Currents, European University Editions, 2010.
3. Jean Perdijon, Le contrôle non destructif par ultrasonics, Hermès Science Publications, 1993.
4. ICNDT, The International Committee for Non-Destructive Testing :<http://www.icndt.org/>
5. EFNDT, European Federation for Non-Destructive Testing :<http://www.efndt.org/>
6. CIVA, non-destructive testing software developed and published by the CEA: <http://www-civa.cea.fr/>
7. Cofrend - Who is the Cofrend?: [www.cofrend.com](http://www.cofrend.com).
8. Precend - Who We Are : [www.precend.fr](http://www.precend.fr)
9. ECND-PdL :[www.ecnd-pdl.fr](http://www.ecnd-pdl.fr)
10. American Society for Non Destructive Testing :[www.asnt.org](http://www.asnt.org)

**Semester :**  
**Teaching unit: UED**  
**Subject 11: Tools for Instrumentation Maintenance**  
**VHS: 10:30 p.m. (Lecture: 1h30)**  
**Credit: 1**  
**Coefficient : 1**

**Teaching objectives:**

This subject provides the student with a reference tool for industry practices in instrumentation maintenance. It aims to help those involved apply good maintenance practices by ensuring the full use of resources, both internal and external.

**Recommended prior knowledge:**

Notions in industrial maintenance.

**Content of the material:**

**Chapter 1: General maintenance organization**

The basic functions of maintenance, Preparing for the use of external services.

**Chapter 2: Implementation of structures**

The organization of maintenance, Communication/information systems, Mobilization of personnel resources.

**Chapter 3: Maintenance Methods**

The common core of maintenance methods, Assessing the risks of failure, Making choices among analytical approaches, Making choices among strategic methods, Implementing methods, ensuring the quality of the maintenance service, Ensuring the safety of maintenance work, Preparing the scheduling of maintenance work.

**Method of evaluation:**

Review: 100%

**Bibliographical references:**

1. *Jean Claude Francastel, Maintenance Engineering from the Design to the Operation of a Property, Edition Dunod, 2007.*
2. *Collective work, Industrial Maintenance, Ed. AFNOR, 1996.*
3. *J. Héng, Pratique de la maintenance préventive: Mécanique–Pneumatique–Hydraulique–Electricité, Froid, Dunod, 2002.*
4. *F. Monchy, La fonction maintenance, formation à la gestion de la maintenance industrielle, Ed. Masson, 1987.*
5. *D. Boitel and C. Hazard, Guide de la maintenance, Ed. Nathan Technique, 1987.*
6. *F. Boucly and A. Ogus, Le management de la maintenance, Ed. AFNOR Gestion, 1988.*
7. *E. Niel, E. Craye, Maîtrise des risques de fonctionnement des systèmes de production, Hermès, 2005.*
8. *N. Limnios, Arbre de défaillance, Hermès, 2005.*
9. *A. Leroy, Dictionnaire d'analyse et de gestion des risques, Hermès, 2005.*
10. *T. Tanzy, Risk Engineering, Hermès, 2005.*

**Semester :**  
**Teaching unit: UED**  
**Subject 12: Industrial maintenance and diagnostics**  
**VHS: 10:30 p.m. (Lecture: 1h30)**  
**Credit: 1**  
**Coefficient : 1**

**Teaching objectives:**

Control of the causes, modes and mechanisms of failures. Mastery of internal and external diagnostic methods. Ability to apply decision tests.

**Recommended prior knowledge:**

Industrial Instrumentation, Sensors, Instrumentation Maintenance Practice, Probability and Statistics.

**Content of the material:**

**Chapter 1: Maintenance Concepts**

Definition of systems and components - Maintenance and dependability - Reliability, Maintainability, Availability, Safety - Maintenance tasks - Maintenance levels - Reliability-based maintenance - Total productive maintenance.

**Chapter 2: Classification of Failures**

Definitions - Classification of failures according to causes - Classification of failures according to degree - Classification of failures according to speed of onset - Classification of failures according to speed of onset and degree - Classification of failures according to date of onset - Classification of failures according to effects - Faults and failures.

**Chapter 3 :D iagnostics and methods**

Concept of causality - Definition of diagnosis - Classification of diagnostic methods - Diagnostic procedure - Measurements - Validation of measurements - Characterization of operation by signature analysis - Detection of a malfunction.

**Chapter 4: Diagnostic methods by functional and material modeling**

Functional analysis techniques - Functional and material trees - Analysis of failure modes and their effects - Fault tree.

**Chapter 5: Diagnostic Methods by Physical Modelling**

Model method - Diagnostic methods by parameter identification - Diagnostic methods by state vector estimation - Diagnostic methods by signature modelling.

**Chapter 6: Diagnostic Methods by Analysis of External Signatures**

External Diagnostic Methods - Pattern Recognition Diagnostic Method - Neural Network Diagnostic Method - Expert Systems Diagnostic Method.

**Chapter 7 :D Diagnostic Error**

Statistical Decision Tests - Bayes Tests - Minimax Test - Neyman-Pearson Test - Composite Tests.

**Method of evaluation:**

Review: 100%

**Bibliographical references:**

1. F. Monchy, Maintenance: Methods and Organisation, Dunod 2000.

2. G. Zwinglestein, *La maintenance based sur la confiance*, Hermes 1996.
3. G. Zwinglestein, *Diagnosis of failures*, Hermes, 1995.
4. *Villemeur, Sureté de fonctionnement des systèmes industriels*, Dunod, 1988.

**Semester:**

**Teaching unit: UED 1.2.2**

**Material 13:**  
**VHS: 10:30 pm (Lecture: 1h30)**  
**Credits: 1**  
**Coefficient: 1**

### **Teaching objectives:**

To allow the student to become familiar with the concepts of digital data transmission, more particularly the different types of networks existing in the industrial world. The focus will be on understanding the different topologies with their advantages and disadvantages vis-à-vis a given industrial plant.

### **Recommended prior knowledge:**

- ✓ Local computer networks ;
- ✓ Sensors;
- ✓ Programmable logic controllers;

### **Material content:**

#### **Chapter 1. General information about fieldbuses (04 weeks)**

1.1-Definitions (Bus, Field, Network, Local Area Network, Industrial Local Area Network (ILN), Enterprise Local Area Network, Some names of industrial local area networks). 1.2-Presentation of the industrial environment. 1.3-Architecture of an ILN (field networks, workshop networks, factory networks). 1.4-Characteristics of an ILR (number of nodes, amount of information, transmission time). 1.5-Characteristics of the data exchanged in an ILR (Nature of the messages exchanged, Size of the messages). 1.6-Role of an ILN in an industrial facility. 1.7-OSI and RLI architecture (Adaptation of the OSI model to RLIs, Physical layer characteristics for ILRs, MAC sublayer characteristics for ILRs).

#### **Chapter 2. : Le bus 485 Modbus (02 weeks)**

Reminder on the RS232 standard. The RS485 link. The Modbus protocol. Modbus addressing and frame.

#### **Chapter 3. The bus CAN (Controller Area Network) (03 weeks)**

Global view of CAN. OSI CAN models. CAN data frames and features. Methods of access and the principle of arbitration. Debits. CAN Hardware. Application layer services. CANopen.

#### **Chapter 4. Profibus (03 weeks)**

Overview of Profibus and features. The three types of Profibus (DP, FMS and PA). How to get there. Industrial Ethernet and Profinet. Debits.

#### **Chapter 5. Overview of Industrial Wireless Networks (03 weeks)**

Technologies, protocols and architectures of industrial wireless networks (WLAN 802.11, Bluetooth, HART protocols, Wireless Profibus, Bluetooth, ZigBee, ...). Security of industrial wireless communication networks.

### **Evaluation method:**

Continuous assessment: 60%; Examination: 40%.

### **Bibliographical references:**

1. G. Pujolle, *Les réseaux, Eyrolles, April 1995.*
2. J-P., Thomesse, *Les réseaux Locaux industriels, Eyrolles, 1994.*
3. P. Vrignat, *Réseaux locaux industriels - Cours et travaux pratiques, Gaëtan Morin, 1999.*
4. P. Rolin, G. Martineau, L. Toutain, A. Leroy, *Les réseaux, principes fondamentals, Hermes, 1996.*
5. J-L. Montagnier, *Pratique des réseaux d'entreprise - Du câblage à l'administration - Du réseau local aux réseaux télécom, Eyrolles, 1996.*
6. Ciame, *Field Networks: Description and Selection Criteria, Hermes, 2001.*

7. *C. Servin, Réseaux et Télécoms: Cours et exercices corrigés Dunod.*
8. *D. Présent, S. Lohier, Transmissions et Réseaux, Cours et exercices correctes, Dunod.*
9. *P. Hoppenot, Introduction to Local Industrial Networks.*
10. *Emad Aboelela, Network simulation experiments, University of Massachusetts Dartmouth.*
11. *Ir. H. Lecocq, Local industrial networks, University of Liège.*
12. *J-F. Hérold, O. Guillotin, P. Anayar, Industrial Computing and Networks in 20 Files*
13. *P. Dumas, Industrial Informatics 2nd edition*
14. *D. Paret, Le Bus CAN Application, Dunod*
15. *F. Lepage, Local Industrial Networks, Hermes*
16. *C. Sindjui, The Great Guide to Industrial Control Systems.*

PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA  
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

University.....  
Faculty.....

Department.....

Sector:.....

Specialty:.....

Academic year 20... /20...

The...../...../20...

**MINUTES CONCERNING THE CHOICE OF DISCOVERY SUBJECTS IN THE FIRST  
YEAR OF THE MASTER'S DEGREE**

The undersigned teachers, after deliberation, have decided on the choice of the subjects of discovery of the master's degree ..... proposed in the framework of this master's degree. In this regard, the following teachers\* undertake to ensure the teaching of these subjects. In the event that the training team chooses a subject whose program is not available in the framework, the head of the course undertakes to send this program to the CPND-ST for enrichment and validation.

\* For each subject, it is possible to indicate the name of the head teacher and possibly the name of a substitute teacher.

Semesters	Discovery Matters	Teachers
S1	Material 1: Material 2:	
S2	Material 1: Material 2:	

Observations :.....  
.....

Teachers' first and last names	Subjects taught	Semester	Signatures
1			
2			
3			
4			
5			
6			
7			
8			
9			

The head of the sector

The head of the department

*Reminders: The nature of the discovery subjects must complement the training and must be chosen according to the needs of the local or regional socio-economic fabric and the availability of teachers specializing in the field.*

Copies to sales representatives/VDPs

PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA  
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

University.....

Faculty.....

Department.....

Sector:.....

Specialty:.....

Academic year 20... /20...

The...../...../20...

**MINUTES CONCERNING THE CHOICE OF DISCOVERY SUBJECTS FOR THE SECOND YEAR OF THE MASTER'S DEGREE**

The undersigned teachers, after deliberation, have decided on the choice of the subjects of discovery of the master's degree ..... proposed in the framework of this master's degree. In this regard, the following teachers\* undertake to ensure the teaching of these subjects. In the event that the training team chooses a subject whose program is not available in the framework, the head of the course undertakes to send this program to the CPND-ST for enrichment and validation.

\* For each subject, it is possible to indicate the name of the head teacher and possibly the name of a substitute teacher.

Semesters	Discovery Matters	Teachers
S3	Material 1: Material 2:	

Observations :.....  
.....

Teachers' first and last names	Subjects taught	Semester	Signatures
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

The head of the sector  
department

The head of the

*Reminders: The nature of the discovery subjects must complement the training and must be chosen according to the needs of the local or regional socio-economic fabric and the availability of teachers specializing in the field.*

Copies to sales representatives/VDPs