الجمهورية الجزائرية الديمقراطية الشعبية People's Democratic Republic of Algeria
وزارة التعليم العالي و البحث العلمي
ministry of higher education and scientific research
اللجنة البيداغوجية الوطنية لميدان العلوم و التكنولوجيا
National Pedagogical Committee of the Sciences and Technologies Field

Harmonized Academic Master

Update 2025

Field	Stream	Specialty
Sciences and Technologies	***Electrotechnics***	***Electrical Controls***

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I – Master's Program Fact Sheet

Access conditions

(Specify the bachelor's specializations that can grant access to the Master's program)

Stream	Harmonized Master	Bachelor's degrees granting access to the Master	Ranking according to the compatibility of the degree	Coefficient assigned to the degree
Electrotechnic	Electrical Controls	Electrotechnic	**1**	**1.00**
		Electromecanical	**2**	**0.80**
		Automatic	**3**	**0.70**
		Industrial Maintenance	**3**	**0.70**
		Other degrees in the ST field	**5**	**0.60**

II – Semester-wise organization sheets of the specialty courses

Semester 1 Master's in Electrical Control

Teaching Unit	Subjects	Credits	Coefficient	Weekly Hours			Semester Hours (15 weeks)	Supplementary Work in Consultation (15 weeks)	Evaluation Method	
	Titled			Course	TD	TP			Continuous control	Exam
Fundamental TU **Code: TUF 1.1.1** **Credits: 10** **Coefficients: 5**	Electrical energy Transmission and Distribution Networks	4	2	1h30	1h30		45h00	45h00	40%	60%
	Advanced Power Electronics	4	2	1h30	1h30		45h00	45h00	40%	60%
	Microprocessors and Microcontrollers	2	1	1h30			22h30	22h30		100%
Fundamental TU **Code: TUF 1.1.2** **Credits: 8** **Coefficients: 4**	Advanced Electrical Machines	4	2	1h30	1h30		45h00	45h00	40%	60%
	Applied Numerical Methods and Optimization	4	2	1h30	1h30		45h00	45h00	40%	60%
Methodological TU **Code: TUM 1.1** **Credits: 11** **Coefficients: 7**	Lab: Microprocessors and Microcontrollers	1	1			1h30	22h30	2h30	100%	
	Lab: Electrical energy Transmission and Distribution Networks	2	1			1h30	22h30	27h30	100%	
	Lab: Advanced Power Electronics	2	1			1h30	22h30	27h30	100%	
	Lab: Applied Numerical Methods and Optimization	2	1			1h30	22h30	27h30	100%	
	Lab: Advanced Electrical Machines	2	1			1h30	22h30	27h30	100%	
	Advanced Programming in Python	2	2	1h30		1h30	45h00	5h00	40%	60%
Discovery TU **Code: TUD 1.1** **Credits: 1** **Coefficients: 1**	renewable energies	1	1	1h30			22h30	02h30		100%
Total Semester 1		**30**	**17**	**10h30**	**6h00**	**9h00**	**382h30**	**367h30**		

Semestre 2 Master'Program in Electrical Control

Teaching Unit	Subjects / Titled	Credits	Coefficient	Weekly Hours: Course	Weekly Hours: TD	Weekly Hours: TP	Semester Hours (15 weeks)	Supplementary Work in Consultation (15 weeks)	Evaluation Method: Continuous control	Evaluation Method: Exam
Fundamental TU Code: TUF 1.2.1 Credits: 10 Coeff.: 5	Modeling and Identification of Electrical Systems	4	2	1h30	1h30		45h00	45h00	40%	60%
	Electrical Control Techniques	6	3	3h00	1h30		67h30	67h30	40%	60%
Fundamental TU Code: TUF 1.2.2 Credits: 8 Coeff.: 4	Sampled Control Systems and Digital control	4	2	1h30	1h30		45h00	45h00	40%	60%
	Fault Diagnosis in Control Systems	4	2	1h30	1h30		45h00	45h00	40%	60%
Methodological TU Code: TUM 1.2 Credits: 9 Coeff.: 5	Lab: Modeling and Identification of Electrical Systems	2	1			1h30	22h30	27h30	100%	
	Lab: Electrical Control Techniques	3	2			3h00	45h30	30h00	100%	
	Lab: Sampled Control Systems and Digital control	2	1			1h30	22h30	27h30	100%	
	Lab: Fault Diagnosis in Control Systems	2	1			1h30	22h30	27h30	100%	
TU Transversal Code: TUT 1.2 Credits: 3 Coeff.: 3	Elements of Applied AI	2	2	1h30	1h30		45	5	40%	60%
	Compliance with Ethical and Integrity Standards	1	1	1h30			22h30	02h30		100%
Total semester 2		**30**	**17**	**10h30**	**6h00**	**9h00**	**382h30**	**367h30**		

Semestre 3 Master's Program in Electrical Control

Teaching Unit	Subjects	Credits	Coefficient	Weekly Hours			Semester Hours (15 weeks)	Supplementary Work in Consultation (15 weeks)	Evaluation Method	
	Tiled			Cours	TD	TP			Continuous Assessment	Exam
Fundamental TU **Code: TUF 2.1.1** **Credits: 8** **Coeff.: 4**	Nonlinear and Advanced Control	6	3	3h00	1h30		67h30	67h30	40%	60%
	Programmable Logic Controllers	2	1	1h30			22h30	22h30		100%
Fundamental TU **Code : TUF 2.1.2** **Credits : 10** **Coefficients : 5**	Artificial Intelligence Techniques	4	2	1h30	1h30		45h00	45h00	40%	60%
	Electrical Control of Industrial Mechanisms	6	3	3h00	1h30		67h30	67h30	40%	60%
Methodological TU **Code: TUM 2.1** **Credits: 9** **Coeff.: 5**	Lab: Nonlinear and Advanced Control	4	2			3h00	45h00	55h00	100%	
	Lab: Artificial Intelligence Techniques / Lab: Real-Time Digital Control Implementation	2	1			1h30	22h30	27h30	100%	
	Lab: Electrical Control of Industrial Mechanisms	2	1			1h30	22h30	27h30	100%	
	Lab: Industrial Programmable Logic Controllers	1	1			1h30	22h30	2h30	100%	
TU Transversale **Code : TUT 2.1** **Credits : 3** **Coefficients : 3**	Reverse Engineering	2	2	1h30	1h30 Atelier		45h30	5h00	40%	60%
	Research and Thesis Design	1	1	1h30			22h30	02h30		100%
Total semester 3		**30**	**17**	**12h00**	**4h30**	**9h00**	**382h30**	**367h30**		

Other Discovery UE (S1, S2, and S3)

1- Entralized and Decentralized Production of Electrical
2- Renewable Energies
3- Electrical energy quality
4- Maintenance and ReliabilityInformatique industrielle
5- Industrial Computing
6- Implementation of Real-Time Digital Control
7- Electrotechnical Materials and Their Applications
8- Special Machines
9- Industrial Ecology and Sustainable Development
10- Transient Regimes of Electrical Systems
11- Industrial Automation
12- Control of Future Energy Systems
13- Electrical Machines in Dynamic Operation
14- Automation and Industrial Computing
15- Others…

Semester 4

Internship in a company concluded with a dissertation and an oral defense

	VHS	Coeff	Credits
Personal Work	550	09	18
Internship	100	04	06
Seminars	50	02	03
Other (Supervision)	50	02	03
Total Semester 4	750	17	30

This table is provided for information purposes only

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

- Scientific Value (Jury Assessment) /6
- Dissertation Writing (Jury Assessment) /4
- Presentation and Response to Questions (Jury Assessment) /4
- Supervisor's Evaluation /3
- Internship Report Presentation (Jury Assessment) /3

III - Detailed Course Program for Semester S1

Semester: 1
Fundamental TU Code : TUF 1.1.1
Subject: Electrical Power Transmission and Distribution Networks
VHS: 45h (course: 1h30, TD: 1h30)
Credits: 4
Coefficient: 2

Objectifs de l'enseignement:

The objective of this course can be divided into two parts: on the one hand, expanding the knowledge acquired during the "Electrical Networks" course at the bachelor's level, and on the other hand, introducing the necessary knowledge related to the management and operation of electrical power networks.

Recommended prerequisite knowledge:

Fundamental laws of electrical engineering (Ohm's law, Kirchhoff's laws, etc.), analysis of AC electrical circuits, complex calculus, and modeling of electrical lines (Electrical Networks course at the bachelor's level).

Course Content:

Chapter 1: Architectures of Electrical Substations (02 weeks)

Overall architecture of the electrical power network, equipment and substation architectures (busbar-coupling substations, circuit-breaker-coupling substations), topologies of transmission and distribution power networks.

Chapter 2: Organization of Electrical Power Transmission

2.1. Power Transmission Lines (03 weeks)

Transmission line calculations: selection of conductor cross-section, insulation, mechanical calculation of lines, operation of transmission lines under steady-state conditions, operation of transmission lines under transient conditions, and high-voltage direct current (HVDC) power transmission.

2.2. Distribution Networks (02 weeks)

Introduction to electrical power distribution, primary distribution, secondary distribution, distribution transformers, reactive power compensation in distribution networks, distribution reliability.

Chapter 3: Operation of MV and LV Electrical Networks (03 weeks)

Protection of HV/MV substations against overcurrents and overvoltages, models of power system elements, voltage regulation, voltage control devices, reactive power control in an electrical network.

Chapter 4: Neutral Grounding Systems (02 weeks)

Neutral grounding schemes (isolated, grounded, impedance-grounded), artificial neutral.

Chapter 5: Voltage Regulation (03 weeks)

Voltage drop in electrical networks, voltage regulation methods (automatic voltage regulation at generator terminals – AVR, reactive power compensation using conventional and modern methods, voltage regulation using an autotransformer), introduction to voltage stability.

Evaluation method:

Continuous control: **40%;** Exam: **60%.**

Bibliographical references:

1. *F. Kiessling et al, 'Overhead Power Lines, Planning, design, construction'. Springer, 2003.*
2. *T. Gonen et al, 'Power distribution', book chapter in Electrical Engineering Handbook. Elsevier Academic Press, London, 2004.*
3. *E. Acha and V.G. Agelidis, 'Power Electronic Control in Power Systems', Newns, London 2002.*
4. *TuranGönen : Electric power distribution system engineering. McGraw-Hill, 1986*
5. *TuränGonen : Electric power transmission system engineering. Analysis and Design. John Wiley & Sons,* ***1988****.*

Semester: 1
Fundamental TU Code: TUF 1.1.2
Subject: Advanced Power Electronics
VHS: 45h (Course: 1h30, TD: 1h30)
Credits: 4
Coefficient: 2

Teaching Objectives:
To provide the electrical circuit concepts behind the different operating modes of inverters in order to enable a deep understanding of their operation. To equip students with the necessary skills to obtain the design criteria for power converters for UPS, drives, etc.
Ability to analyze and understand the different operating modes of various power converter configurations.Ability to design different single-phase and three-phase inverters.
Recommended prerequisite knowledge:
Power components, basic power electronics.
Course Content:
Chapter 1: Modeling and Simulation Methods of Power Semiconductors *(***02 weeks***)*
Idealized characteristics of different types of semiconductors, logical equations of semiconductors, simulation methods of static converters.
Chapter 2: Switching Mechanisms in Static Converters *(***03 weeks***)*
Principle of natural commutation, principle of forced commutation, calculation of switching losses.
Chapter 3: Design Methods of Naturally Commutated Static Converters *(***02 weeks***)*
Switching rules, definition of the switching cell, different types of sources, power exchange rules, direct and indirect converters (example: study of a cycloconverter).
Chapter 4: Design Methods of Forced-Commutated Static Converters (03 weeks)

- PWM inverter
- Sinusoidal current absorption rectifier
- PWM AC voltage controller
- Switched-mode power supplies

Chapter 5: Multilevel Inverter *(***03 weeks***)*
Multilevel concept, topologies, comparison of multilevel inverters, PWM control techniques for single-phase and three-phase impedance-source PWM inverters.
Chapter 6: Power Quality of Static Converters *(***03 weeks***)*

- Harmonic pollution caused by static converters (case study: rectifier, AC voltage controller)
- Harmonic analysis in voltage inverters
- Introduction to mitigation techniques

Evaluation Method:
Continuous control: **40%**; Exam: **60%**.

Bibliographic References:

1. *Electronique de puissance, de la cellule de commutation aux applications industrielles. Cours et exercices, A. Cunière, G. Feld, M. Lavabre, éditions Casteilla, 544 p. 2012.*
2. *-Encyclopédie technique « Les techniques de l'ingénieur », traité de Génie Electrique, vol. D4 articles D3000 à* ***D3300****.*

Semester: 1
Fundamental TU Code : TUF 1.1.1
Subject: Microprocessor and Microcontroller
VHS: 22h30 (Course: 1h30)
Credits: 2
Coefficient: 1

Teaching Objectives:
Understand the structure of a microprocessor and its purpose. Differentiate between a microprocessor, a microcontroller, and a computer. Understand memory organization. Learn assembly language programming. Understand the use of I/O interfaces and interrupts. Use of microcontroller (programming, system control).
Recommended Prerequisite Knowledge:
Combinational and sequential logic, industrial automation.

Course Content:

Chapter 1: Microprocessor Architecture and Operation (03 weeks)
Structure of a computer, information flow in a computer, hardware description of a microprocessor, microprocessor operation, memories.
Example: Intel 8086 microprocessor.
Chapter 2: Assembly Language Programming (02 weeks)
General concepts, instruction set, programming methods.
Chapter 3: Interrupts and Input/Output Interfaces (03 weeks)
Definition of an interrupt, handling of an interrupt by the microprocessor, addressing of interrupt subroutines, addressing of I/O ports, management of I/O ports.
Chapter 4: Microcontroller Architecture and Operation (03 weeks)
Hardware description of a microcontroller and its operation. Microcontroller programming.
Example: PIC microcontroller.
Chapter 5: Applications of Microprocessors and Microcontrollers (04 weeks)
LCD-keyboard interface, signal generation via port interfaces for converters, motor control, DC/AC device control, frequency measurement, data acquisition systems.

Evaluation Method:
Exam: **100%**.

Bibliographic References:

1. *R. Zaks et A. Wolfe. Du composant au système – Introduction aux microprocesseurs. Sybex, Paris, 1988.*
2. *M. Tischer et B. Jennrich. La bible PC – Programmation système. Micro Application, Paris, 1997.*
3. *R. Tourki. L'ordinateur PC – Architecture et programmation – Cours et exercices. Centre de Publication Universitaire, Tunis, 2002.*
4. *H. Schakel. Programmer en assembleur sur PC. Micro Application, Paris, 1995.*
5. *E. Pissaloux. Pratique de l'assembleur I80x86 – Cours et exercices. Hermès, Paris,* ***1994***

Semester: 1
Fundamental TU Code : TUF 1.1.2
Subject: Advanced Electrical Machines
VHS: 45h (Course: 1h30, TD 1h30)
Credits: 4
Coefficient: 2

TeachingObjectives:
At the end of this course, the student will be able to establish the general equations of electromechanical energy conversion applied to synchronous, asynchronous, and direct current machines, and determine their characteristics under steady-state or dynamic conditions. This knowledge also allows for understanding the integration of machines with static converters.

RecommendedPrerequisiteKnowledge:
Three-phase AC circuits, electrical power, magnetic circuits, single-phase and three-phase transformers, DC and AC electrical machines (motor and generator operation).

Course Content:

Chapter1:GeneralPrinciples (03 weeks)
Principle of electromechanical energy conversion. Stator/rotor coupling principle: the primitive machine. Windings of electrical machines. Calculation of magnetomotive forces. Mechanical equation.

Chapter 2: Synchronous Machines (04 weeks)
Overview and formulation of synchronous machines with smooth poles. Study of synchronous machine operation. Different excitation systems. Armature reaction. Salient-pole synchronous machines with and without damper windings. Potier diagrams, two-reactance diagram, and Blondel diagram. Elements of permanent magnet machines. Alternators and parallel connection. Synchronous motors and starting methods.

Chapter 3: Asynchronous Machines (04 weeks)
Overview. Formulation. Equivalent circuits. Torque of the asynchronous machine. Characteristics and diagrams of asynchronous machines. Motor/generator operation, starting, braking. Deep-bar and double-cage motors. Single-phase asynchronous motors.

Chapter 4: Direct Current Machines (04 weeks)
Structure of DC machines. Equations of DC machines. Starting, braking, and speed control of DC motors. Commutation phenomena. Saturation and armature reaction. Interpoles for commutation. Motor/generator operation.

Evaluation Method:
Continuous control: **40%**; Exam: **60%**.

Bibliographic References:

1. *J.-P. Caron, J.P. Hautier : Modélisation et commande de la machine asynchrone, Technip, 1995.*
2. *G. Grellet, G. Clerc : Actionneurs électriques, Principes, Modèles, Commandes, Eyrolles, 1996.*
3. *J. Lesenne, F. Notelet, G. Séguier : Introduction à l'électrotechnique approfondie, Technique et Documentation, 1981.*
4. *Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2010.*
5. *P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2008.*
6. *A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 5th Edition,* ***1992***

Semester: 1
Fundamental TU Code : TUF 1.1.2
Subject : Applied Numerical Methods and Optimization
VHS: 45h (Course: 1h30, TD 1h30)
Credits: 4
Coefficient: 2

TeachingObjectives:
The objective of this course is to present the necessary tools for numerical analysis and optimization, with or without constraints, for physical systems in engineering.
Recommended Prerequisite Knowledge:
Mathematics, programming, and proficiency in the MATLAB environment.

Course Content:

Chapter I: Review of Some Numerical Methods (3 weeks)
- Solving systems of nonlinear equations using iterative methods.
- Numerical integration and differentiation.
- Methods for solving ordinary differential equations (ODEs): Euler methods, Runge-Kutta methods, Adams method.
- Solving ODE systems.

Chapter II: Partial Differential Equations (PDEs) (6 weeks)
- Introduction and classification of PDE problems and boundary conditions.
- Methods for solving PDEs: Finite Difference Method (FDM), Finite Volume Method (FVM), Finite Element Method (FEM).

Chapter III: Optimization Techniques (6 weeks)
- Definition and formulation of an optimization problem.
- Single-objective and multi-objective optimization, with or without constraints.
- Unconstrained optimization algorithms (deterministic and stochastic methods).
- Handling constraints (transformation methods, direct methods).

Evaluation Method:
Continuous control: **40%**; Exam: **60%**.

Bibliographic References:

1. *G.Allaire, Analyse Numérique et Optimisation, Edition de l'école polytechnique,2012*
2. *S.S. Rao, 'Optimization – Theory and Applications', Wiley-Eastern Limited, 1984*
3. *A. fortin, Analyse numérique pour ingénieurs, Presses internationales polytechnique, 2011.*
4. *J. Bastien, J. N. Martin, Introduction à l'analyse numérique : Application sous Matlab, Dunod, 2003.*
5. *A. Quarteroni, F. Saleri, P. Gervasio, Calcul scientifique, Springer, 2008.*
6. *T. A. Miloud, Méthodes numériques : Méthode des différences finis, méthode des intégrales et variationnelles, Office des publications universitaires, 2013.*
7. *J. P. Pelletier, Techniques numériques appliquées au calcul scientifique, Masson, 1982.*
8. *F. Jedrzejewski, Introduction aux méthodes numériques, springer, 2001.*
9. *P. Faurre, Analyse numériques, notes d'optimisation, Ecole polytechnique, 1988.*
10. *Fortin. **Analyse numérique pour ingénieurs**, presses internationales polytechnique, 2011.*
11. *J. Bastien, J.N Martin. **Introduction à l'analyse numérique : Application sous Matlab**, Dunod, 2003.*
12. *Quarteroni, F.Saleri, P. Gervasio. **Calcul scientifique**, Springer, **2008.***

Semester 1
Methodological TU
Code : TUM 1.1
Subject: TP : - µ-processors and µ-controllers
VHS: 22h30 (TP: 1h30)
Credits: 1
Coefficient: 1

Teaching Objectives:
Learn assembly language programming. Understand the principle and execution steps of each instruction. Learn the use of I/O interfaces and interrupts. Use of the microcontroller (programming and system control).

Recommended Prerequisite Knowledge:
Combinational and sequential logic, industrial automation, algorithmics.

Course Content:

TP1: Introduction to a programming environment on a microprocessor *(01 week)*
TP2: Programming arithmetic and logic operations on a microprocessor *(01 week)*
TP3: Using video memory in a microprocessor *(01 week)*
TP4: Microprocessor memory management *(02 weeks)*
TP5: Stepper motor control using a microprocessor *(02 weeks)*
TP6: Screen management *(01 week)*
TP7: Programming the PIC microcontroller *(02 weeks)*
TP8: Stepper motor control using a PIC microcontroller *(02 weeks)*

Evaluation Method:
Continuous control: **100%**

Bibliographic References:

1. *R. Zaks et A. Wolfe. Du composant au système – Introduction aux microprocesseurs. Sybex, Paris, 1988.*
2. *M. Tischer et B. Jennrich. La bible PC – Programmation système. Micro Application, Paris, 1997.*
3. *R. Tourki. L'ordinateur PC – Architecture et programmation – Cours et exercices.Centre de Publication Universitaire, Tunis, 2002.*
4. *H. Schakel. Programmer en assembleur sur PC. Micro Application, Paris, 1995.*
5. *E. Pissaloux. Pratique de l'assembleur I80x86 – Cours et exercices. Hermès, Paris, 1994*
6. *P. Mayeux Apprendre la programmation des PIC Mid Range par l'expérimentation et la simulation DUNOD 2010*
7. *A. Reboux. S'initier à la programmation des PIC Basic et assembleur – DUNOD* ***2002***

Semester: 1
Methodological TU Code : TUM 1.1
Subject: TP : Electrical energy Transmission and Distribution Networks
VHS: 22h30 (TP: 1h30)
Credits: 2
Coefficient: 1

Teaching Objectives:
Enable the student to acquire all the necessary tools to manage, design, and operate electro-energy systems, and more specifically, electrical power networks.

Recommended Prerequisite Knowledge:
General knowledge of electrical transmission and distribution networks.

Course Content:
Lab 1: Voltage regulation using a synchronous motor
Lab 2: Power distribution and voltage drop calculation
Lab 3: Voltage regulation by reactive power compensation
Lab 4: Neutral grounding schemes
Lab 5: Interconnected networks

Evaluation Method:
Continuous control: **100%**

Bibliographic References:

1. *Sabonnadière, Jean Claude, Lignes et réseaux électriques, Vol. 1, Lignes d'énergie électriques, 2007.*
2. *Sabonnadière, Jean Claude, Lignes et réseaux électriques, Vol. 2, Méthodes d'analyse des réseaux électriques, 2007.*
3. *Lasne, Luc, Exercices et problèmes d'électrotechnique : notions de bases, réseaux et machines électriques, 2011.*
4. *J. Grainger, Power system analysis, McGraw Hill , 2003*
5. *W.D. Stevenson, Elements of Power System Analysis, McGraw Hill,* ***1998****.*

Semester: 1
Methodological TU Code : TUM 1.1
Subject: TP Advanced Power Electronics
VHS: 22h30 (TP: 1h30)
Credits: 2
Coefficient: 1

Teaching Objectives:
Enable the student to understand the operating principles of new power electronics converter structures.

Recommended Prerequisite Knowledge:
Basic principles of power electronics.

Course Content:
Lab 1: New converter structures
Lab 2: Power factor improvement
Lab 3: Harmonic elimination
Lab 4: Static reactive power compensators

Evaluation Method:
Continuous control: **100%**

Bibliographic References:

1. *GuySéguier et Francis Labrique, «Les convertisseurs de l'électronique de puissance - tomes 1 à 4» ,*
2. *Ed. Lavoisier Tec et Documentation très riche disponible en bibliothèque. - Site Internet : « Cours et Documentation »*
3. *Valérie Léger, Alain Jameau Conversion d'énergie, électrotechnique, électronique de puissance. Résumé de cours, problèmes*
4. *corrigés », , : ELLIPSES MARKETIN**G***

Semester: 1
Methodological TU Code : TUM 1.1
Subject: Applied Numerical Methods and Optimization
VHS: 22h30 (TP: 1h30)
Crédits: 2
Coefficient: 1

Teaching Objectives:
Program the numerical solution methods and apply them to optimization problems.

Recommended Prerequisite Knowledge:
Algorithmics and programming.

Course Content:

- **Introduction to the MATLAB Environment** (Introduction, basic aspects, comments, vectors and matrices, M-Files or scripts, functions, loops and control structures, graphics, etc.) **(01 week)**
- **Write programs to:**
  - Calculate integrals using the following methods: Trapezoidal, Simpson, and general methods **(01 week)**
  - Solve ordinary differential equations (ODEs) and ODE systems using Euler, 2nd and 4th order Runge-Kutta methods *(02 weeks)*
  - Solve linear and nonlinear equation systems: Jacobi, Gauss-Seidel, Newton-Raphson **(01 week)**
  - Solve PDEs using FDM and FEM for the three types of equations (elliptic, parabolic, and hyperbolic) **(06 weeks)**
  - Minimize a multivariable function without constraints *(02 weeks)*
  - Minimize a multivariable function with constraints (inequalities and equalities) **(02 weeks)**

Evaluation Method:
Continuous control: **100%**

Bibliographic References:

1. G.Allaire, Analyse Numérique et Optimisation, Edition de l'école polytechnique,2012
2. Computational methods in Optimization, Polak , Academic Press,1971.
3. Optimization Theory with applications, Pierre D.A., Wiley Publications,1969.
4. Taha, H. A., Operations Research: An Introduction, Seventh Edition, Pearson Education Edition, Asia, New Delhi ,2002.
5. S.S. Rao,"Optimization – Theory and Applications", Wiley-Eastern Limited, **1984**.

Semester: 1
Methodological TU Code : TUM 1.1
Subject: TP Advanced Electrical Machines
VHS: 22h30 (TP: 1h30)
Crédits: 2
Coefficient: 1

Teaching Objectives:
Complete, consolidate, and verify the knowledge already acquired in the course.

Recommended Prerequisite Knowledge:
Good proficiency in computer tools and MATLAB-SIMULINK software.

Course Content:

1. Electromechanical characteristics of the asynchronous machine
2. Circle diagram
3. Standalone operation of an asynchronous generator
4. Coupling of an alternator to the grid and its operation with a synchronous motor
5. Determination of the parameters of a synchronous machine

Evaluation Method:
Continuous control: **100%**

Bibliographic References:

1. *Th. Wildi, G. Sybille "électrotechnique ", 2005.*
2. *J. Lesenne, F. Noielet, G. Seguier, "Introduction à l'électrotechnique approfondie" Univ. Lille. 1981.*
3. *MRetif "Command Vectorielle des machines asynchrones et synchrone" INSA, cours Pedg. 2008.*
4. *R. Abdessemed "Modélisation et simulation des machines électriques " ellipses,***2011***.*

Semester: S1
Methodological TU: TUM 1.1
Subject : Programmation avancée en Python
VHS:45h00 (Course 1h30, TP 1h30)
Crédits:2
Coefficient:2

Course Objectives:
Targeted Skills:

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

Objectives:

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

Required Materials:

- A computer with Python installed
- Python libraries: NumPy, Pandas, Scikit-learn, Matplotlib, os.listdir, os.path.exists, os.mkdir, os.rmdir, Matplotlib, Seaborn, Plotly, Requests, BeautifulSoup, Tkinter, PyQT, …
- TensorFlow, PyTorch, …

Prerequisites: Python programming

Course Content:

Chapter 1: Review of Python Programming (02 weeks)

1. Introduction: Basic computer science concepts and digital tools, Python installation
2. Introduction to operating systems: Roles, types (Linux, Windows, …), priority management
3. Overview of computer networks (principles, IP address, DNS, Internet, …)
4. Basic programming: Interactive and script modes, variables, data types, operators, conditional structures and loops (if, for, while)
5. Functions and essentials: Predefined functions and user-defined functions, standard modules (math, random), strings, lists, basic data manipulation
6. Files, lists, tuples, dictionaries
7. Exercises:
    - Python learning exercises
    - Exercises using the libraries covered in class (math, random, NumPy, Pandas, …)

Chapter 2: Programming and Automation (04 weeks)

1. Principles of Task Automation
    - Python libraries for automation:
        - Pandas and NumPy
        - os, shutil: file and folder manipulation
        - openpyxl or pandas: working with Excel or CSV files
    - Definitions and examples of automation (e.g., sending emails)
2. File manipulation with Python:
    - Use libraries to:
        - Browse folders (`os.listdir`)
        - Check for existence of files/folders (`os.path.exists`)
        - Create or delete folders (`os.mkdir`, `os.rmdir`)
        - Visualize data: Matplotlib, Seaborn, Plotly
        - Requests for interacting with APIs
        - BeautifulSoup for web scraping
        - Tkinter, PyQT for graphical data visualization
    - Copy or move files with shutil
    - Search, sort, and generate simple reports
    - Serialization and deserialization (using the pickle module)
    - Object serialization and handling large files (streaming)
3. Exercises:
    - Using openpyxl and pandas to read, modify, and write Excel or CSV files to:
        - Create automatic reports
        - Automatically extract data
    - Writing scripts to:
        - Process text files (search, sort)
        - Automate technical calculations
        - Manage simple reports (PDF, Excel)
        - …
    - Sorting and searching algorithms, insertion sort
    - Implement a search function in a list
    - File operations
    - Secure navigation (simple network setup, password management)

Chapter 3: Advanced Excel Training (02 weeks)

1. Macro principles and creating a simple macro
2. Pivot tables
3. Histograms
4. Bar charts
5. Spider (radar) charts
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 project management?
    - GanttProject interface
2. Tasks (creation, modification, organization)
3. Time management (project start and end dates)
4. Resource management

5. Exercises on GanttProject

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

1. **Code Organization:**
   - Custom functions, parameters, return values
   - Modules, imports, and packages
2. **Complex Data Structures:**
   - Lists, tuples, and dictionaries: creation, modification, deletion, iteration
3. **Fundamental Concepts of Object-Oriented Programming (OOP):**
   - Classes, objects, attributes, and methods
   - Public, private, and protected attributes
4. **Special Methods:**
   - `__init__`, `__str__`, `__repr__`, `__len__`
5. **Advanced Concepts:**
   - Encapsulation, abstraction, inheritance, polymorphism
   - Advanced inheritance, decorators, design patterns, metaclasses
6. **Exercises**

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

1. **Introduction to Common AI Datasets:**
   - Iris, MNIST, CIFAR-10, Boston Housing, ImageNet
2. **Data Preprocessing for Machine Learning:**
   - Cleaning, normalization, encoding, data splitting
   - Cross-validation
3. **Feature Engineering Techniques:**
   - Feature selection, feature creation, dimensionality reduction
4. **Essential Libraries for AI Model Development:**
   - scikit-learn, TensorFlow, Keras, PyTorch

Practical Work (Labs):

TP 01: Mastering Python Basics
(Control structures, types, loops, simple functions)

1. Introduction
2. Reading and processing text files
3. Managing simple reports (PDF, Excel)

TP 02: Mini Project – Task Automation with Python

- Create a project specification for automatically identifying and sending reports via email using 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 chart
  4. Send results via Python

TP03: Excel Programming

1. Implement the dashboard seen in tutorials

2. Create automated Excel tables
3. Simple macros
4. Conditional formulas
5. VLOOKUP

TP 04: Organizing a Meeting in GanttProject

1. Create a new project:
   - Project name: "Meeting …"
   - Start date: date and time of the meeting
   - Estimated duration: total duration of the meeting
2. Define tasks:
   - Agenda items (each item becomes a task)
   - Sub-tasks: if an item is composed, create corresponding sub-tasks
   - Initial and final tasks (e.g., “Participant welcome,” “Meeting closure”)
3. Define resources:
   - Participants (each participant is a resource)
   - Equipment (computer, projector, etc.)
4. Estimate durations:
   - Duration for each agenda item
   - Transition time between items
5. Create the Gantt chart:
   - Visualize the agenda
   - Identify key points
6. Track progress in real-time (Gantt chart projection)

TP 05: Advanced Structures and Code Organization

- Custom functions, dictionaries, modules, and modular organization

TP 06: Advanced Object-Oriented Programming in Python

- Encapsulation, inheritance, special methods, simple design patterns

TP 07: File Handling and Data Analysis

- Reading/writing files, text processing, introduction to Pandas and NumPy

TP08: Data Preparation and Processing for Artificial Intelligence

- Loading AI datasets, cleaning, transformation, feature selection

Final Project
Title: Analysis and Visualization of a Dataset + Simple Predictive Model
Skills Applied: Data reading, OOP, advanced structures, Pandas, Scikit-learn (oral presentation + written report)
Evaluation Method: Exam: **60%,** Continuous control: **40%**
Bibliography:
E.Schultz et M.Bussonnier (2020) : Python pour les SHS. Introduction à la programmation de données. Presses Universitaires de Rennes.

[1] . C.Paroissin, (2021) : Pratique de la data science avec R : arranger, visualiser, analyser et présenter des données. Paris : Ellipses, DL 2021.
[2] . S.Balech et C.Benavent : NLP texte minig V4.0, (Paris Dauphine – 12/2019) : lien : https://www.researchgate.net/publication/337744581_NLP_text_mining_V40_-_une_introduction_-_cours_programme_doctoral
[3] . Allen B. Downey Think Python: How to Think Like a Computer Scientist, O'Reilly Media, 2015;
[4] . Ramalho, L.. Fluent Python. " O'Reilly Media, Inc.", 2022;
[5] . Swinnen, G..Apprendre à programmer avec Python 3. Editions Eyrolles, 2012;
[6] . Matthes, E. Python crash course: A hands-on, project-based introduction to programming. no starch press, 2019
[7] . Cyrille, H. (2018). Apprendre à programmer avec Python 3. Eyrolles, 6ème édition. ISBN: 978-2212675214
[8] . Daniel, I. (2024). Apprendre à coder en Python, J'ailu
[9] . Nicolas, B. (2024). Python, du grand débutant à la programmation objet Cours et exercicescorrigés, 3eme édition, Ellipses
[10] . Ludivine, C. (2024). Selenium Maîtrisezvos tests fonctionnels avec Python, Eni

Online Resources:

- Documentation officielle Python : docs.python.org
- Exercices Python sur Codecademy : codecademy.com/learn/learn-python-3
- W3Schools Python Tutorial : w3schools.com/python/

Semester: 1
Discovery TU Code: TUD 1.1
Subject : Elective Course 2
VHS : 22h30 (course : 1h30)
Crédits : 1
Coefficient : 1

Note:
The specialty team may freely choose an elective course offered in the curriculum or select another elective course from those proposed, according to the needs and interests of the program.

IV - Detailed Course Program for Semester S2

Semester: 2
Fundamental TU Code : TUF 1.2.1
Subject: Modeling and Identification of Electrical Systems
VHS: 45h (Course: 1h30, TD 1h30)
Credits: 4
Coefficient: 2

Teaching Objectives:
Acquire and master fundamental concepts and basic methods for developing representation models that describe input-output behavior from experimental measurements, as well as techniques for identifying a process to be controlled, with the goal of designing high-performance control systems.

Recommended Prerequisite Knowledge:
Mathematical foundations and basic knowledge of control systems.

Course Content:

Chapter 1: Systems and Experiments (01 week)
General concepts, types of models, modeling and simulation, how to obtain a model

Chapter 2: Mathematical Model (02 weeks)
Block diagram of a system, characteristic variables, internal and external representations of a system

Chapter 3: Modeling of Electrical Systems (02 weeks)
Modeling passive and active components and basic electrical circuits, application examples

Chapter 4: Modeling Tools (02 weeks)
Bond Graphs (BG) or Causal Information Graphs (CIG) – Application to electrical circuits

Chapter 5: General Concepts of System Identification (02 weeks)

- Definitions, steps, SBPA generation, choice of model structure (AR, ARMA, ARMAX, etc.)
- Review of basic control methods: System time response, frequency-domain approach, direct identification from first- and second-order system responses (time and frequency), instrumental variable method
- Model fitting principle: Linear model with respect to parameters, minimization of fitting criterion, calculation of optimal solution

Chapter 6: Graphical Identification Methods (02 weeks)
Strejc method, Broïda method, etc.

Chapter 7: Numerical Identification Methods (02 weeks)
Recursive and non-recursive methods

Chapter 8: Estimation and Observation (02 weeks)

- Estimation of electrical systems (e.g., Gopinath estimator)
- Deterministic observation (Luenberger observer)
- Non-deterministic or stochastic observers (Kalman filter)

Evaluation Method:
Continuous control: **40%**; Exam: **60%**

Bibliographic References:

1. I.D. Landau, "Identification des systèmes", Hermès, 1998.
2. E. Duflos, Ph. Vanheeghe, "Estimation Prédiction", Technip, 2000.
3. T. Soderstrom, P. Stoica, "System Identification", Prentice Hall, 1989.
4. R. Hanus, "Identification à l'automatique", DE Boeck, 2001.
5. L. Lennart, "System Identification: Theory for the User", Second edition, Prentice Hall 1999.
6. P. Borne, Geneviève Dauphin-Tanguy, Jean-Pierre Richard, "Modélisation et identification des processus", Technip, 1992.
7. R. Ben Abdenour, P. Borne, M. Ksouri, M. Sahli, "Identification et commande numérique des procédés industriels", Technip, 2001.
8. E. Walter, L. Pronzato, "Identification of Parametric Models from Experimental Data", Springer, **1997**.

Semester: 2
Fundamental TU Code : TUF 1.2.1
Subject: Electrical Control Techniques
VHS: 67h30 (Course: 3h00, TD 1h30)
Credits: 6
Coefficient: 3

Teaching Objectives:

- Acquire fundamental knowledge to design a drive system (motor and power electronics) for a variable-speed application, meeting predefined specifications, based on DC or AC machines.
- Size the necessary PID controllers for controlling electric machines according to specifications using an appropriate method.
- Evaluate and compare the performance of different control strategies.

Recommended Prerequisite Knowledge:

Mathematics, basic knowledge of electric machines, power electronics converters, and control theory.

Course Content:

Chapter 1: Variable-Speed Electric Drives (01 week)

Drive system architecture, importance of variable speed, drive structures, comparison of different drives

Chapter 2: Modeling of Asynchronous and Synchronous Machines for Control (04 weeks)

Various three-phase to two-phase transformations, dynamic models of asynchronous and synchronous machines in the Park two-phase reference frame, functional diagrams

Chapter 3: Control Strategies for Asynchronous Machines (05 weeks)

- Review of scalar control
- Vector control: Principles of vector control, choice of reference frame and control strategy, rotor-flux-oriented vector control, stator-flux-oriented vector control
- Direct torque control of asynchronous motors: Control strategies, torque control, power control

Chapter 4: Control Strategies for Synchronous Machines (05 weeks)

Starting issues of synchronous machines, machine-converter association, synchronous motor at variable speed, self-control, vector control, torque control of synchronous machines, DPC control of synchronous machines

Evaluation Method:

Continuous control: **40%**; Exam: **60%**

Bibliographic References:

1. Modélisation et commande de la machine asynchrone, J.P. Caron et J.P. Hautier, Technip, 1995
2. Control of Electrical Drives, W. Leonard, Springer-Verlag, 1996
3. Vector control of AC machines, Peter Vas, Oxford University Press, 1990
4. Méthodes de commande des machines électrique, R. Husson, Hermès.
5. Power Electronics and AC Drives, Prentice-Hall, B.K. Bose, 1986
6. Modern Power Electronics and AC Drives, B-K. Bose, Prentice-Hall International Edition, 2001.
7. Actionneurs électriques, Guy Grellet et Guy Clerc, Eyrolles, 1997
8. Commande des moteurs asynchrone, Modélisation, Contrôle vectoriel et DTC, Volume 1, C. Canudas De 9. Wit, Edition Hermès Sciences, Lavoisier, Paris **2004**.

Semester: 2
Fundamental TU Code : TUF 1.2.2
Subject: Sampled Control Systems and Digital control
VHS: 45h00 (Course: 1h30, TD 1h30)
Credits: 4
Coefficient: 2

Teaching Objectives:
Understand sampling, the difference between continuous, sampled, and discrete systems. Know and master the mathematical tool "z-transform." Understand discrete models. Perform analysis of sampled (discrete) systems and design digital (discrete) controllers such as PID, RST, and state-feedback controllers. Be able to implement digital (discrete) controllers.

Recommended Prerequisite Knowledge:
Understanding of sampling, differences between continuous, sampled, and discrete systems. Knowledge and mastery of the "z-transform" mathematical tool. Understanding of discrete models. Ability to analyze sampled (discrete) systems and design digital (discrete) controllers: PID, RST, and state-feedback. Ability to implement digital (discrete) controllers.

Course Content:

Chapter 1: Structure of a Digital Control System (01 week)
History, advantages and disadvantages of digital control, general structure of a digital control system, A/D and D/A conversions, samplers/holds.

Chapter 2: Sampling and Signal Reconstruction (01 week)
Sampling, Shannon sampling theorem, practical considerations, signal reconstruction.

Chapter 3: Z-Transform: Properties and Applications (02 weeks)
Definitions, properties of the z-transform, z-transform of selected signals, inverse z-transform, examples of applications.

Chapter 4: Sampled (Discrete) Systems (02 weeks)
Definitions, representation using difference equations, forward/backward shift operators, representation via impulse response, representation via discrete transfer function (Z-domain transfer), state-space representation, functional block algebra (simplification of blocks/diagrams).

Chapter 5: Analysis of Sampled Systems (03 weeks)
Introduction, stability, accuracy, stability-accuracy trade-off. Time-domain analysis (impulse response, step response, effects of poles and zeros), frequency-domain analysis, stability criteria (Schur-Cohn, Jury, Routh-Hurwitz, discrete Nyquist, discrete Evans locus).

Chapter 6: Digital PID Controller (02 weeks)
Continuous PID, discretization of continuous PID, synthesis in the Z-plane, practical implementation of PID controllers.

Chapter 7: Digital RST Controller (02 weeks)
Synthesis in the continuous case, synthesis in the discrete (sampled) case, practical implementation of RST controllers.

Chapter 8: Digital State-Feedback Control (02 weeks)
Synthesis in the continuous case, synthesis in the discrete (sampled) case, practical implementation of state-feedback controllers.

Evaluation Method:
Continuous control: **40%**; Exam: **60%**

Bibliographic References:

1. J.R. Ragazzini, G. F. Franklin, « Les systèmes asservis échantillonnés », Dunod, 1962.
2. D. Viault, Y. Quenec'hdu, « Systèmes asservis échantillonnés », ESE, 1977.
3. C. Sueur, P. Vanheeeghe, P. Borne, "Automatique des systèmes échantillonnés : éléments de cours et exercices résolus", Technip, 5 décembre 2000.
4. P. Borne. G.D.Tanguv. J. P. Richard. F. Rotella, I. Zambetalcis, "Analyse et régulation de processus industriels-régulation numérique", Tome 2-Editions Technip, 1993.
5. Emmanuel Godoy, EricOstertag, "Commande numérique des systèmes: Approches fréquentielle et polynomiale", Ellipses Marketing ,2004.
6. H. Buhler, "Réglages Echantillonnés", Tome 1, Edition Dunod.
7. Dorf & Bishop, "Modern Control Systems", Addison-Wesley, 1995
8. J. L Abatut, "Systèmes et Asservissement Linéaires Echantillonnés", Edition Dunod.
9. T.J. Katsuhiko, "Modern Control Engineering", 5th Edition, Prentice Hall.
10. R. Longchamps, "Commande Numérique des systèmes dynamiques", Presse Polytechnique, **2006**.

Semester: 2
Fundamental TU Code : TUF 1.2.2
Subject: Fault Diagnosis in Control Systems
VHS: 45h00 (Course: 1h30, TD 1h30)
Credits: 4
Coefficient: 2

Teaching Objectives:
Industrial fault diagnosis is based on the knowledge of symptom(s) to determine the cause(s). This course enables students to acquire essential knowledge to prevent failures, ensuring reliability and service continuity in an electrical control system.

Recommended Prerequisite Knowledge:
Electric machines, Electrical circuits, Signal theory, Numerical analysis

Course Content:

Chapter 1: Introduction to Fault Diagnosis Techniques (03 weeks)
Definitions: Purpose of diagnosis, Normal operation, Failure and defect, Malfunction, Disturbance, Residual, Detection, Fault localization, Fault identification, Signature, Monitoring, Supervision. Diagnosis methodology: How to perform a diagnosis? Logical steps in fault investigation, localization of defective components offline and online, diagnosing and finding the cause. Intervention methodology: Continuous monitoring, inspection, replacement of defective components and verification, intervention report. Fault classification: location, modeling, temporal characteristics, monitoring using models: physical redundancy, analytical redundancy, fault detection and isolation (FDI), diagnostic principle: diagnostic architecture, residual generation based on models, obtaining signature tables, model-based diagnostic methods, observer-based approaches.

Chapter 2: Fault Diagnosis Tools (02 weeks)
Sensors, signal visualization, signal processing, spectral analysis: tools and techniques.

Chapter 3: Inspections, Guidelines, Interventions (03 weeks)
Specificity of industrial installations in terms of inspections, diagnosis of control and power equipment, use of manufacturer data and reference values, mastering degradation curves and operational threshold settings.

Chapter 4: Preventive Maintenance of Equipment (02 weeks)
Reading electrical diagrams of power, control, and/or remote-control circuits. Periodic checking of connector tightness, conductor condition, heating. Monitoring leakage currents, rated current, and voltage.

Chapter 5: Diverse Practical Case Studies (03 weeks)
Motor, conveyor, control system.

Chapter 6: Introduction to Intelligent Methods in Diagnosis (02 weeks)
Expert systems, state graphs, fuzzy logic, neural networks, genetic trees, etc.

Assessment Method:
Continuous assessment: 40%; Exam: 60%

Bibliographic References:

1. J. Montmain, J. Ragot, D. Sauter, Supervision des procédés complexes, Lavoisier, 2007.
2. L. Ljung, Systems Identification: theory for the User. Prentice-Hall, 2nd edition, 1999.
3. P.S.R. Murty, Power System Analysis, BS Publications, 2007.
4. D. Brown, D. Harrold, R. Hope, Control System Power and Grounding Better Practice, Elsevier, 2004.
5. G. Cullman, Eléments de calcul informationnel, Bibliothèque de l'ingénieur électricien-mécanicien. Ed. Albin Michel.
6. J.D. Glover, M.S. Sama, T.J. Overbye, "Power Systems Analysis and Design", 4th Edition, Thompson-Engineering.

Semester: 2
Methodological TU Code : TUM 1.2
Subjet: TP Modeling and Identification of Electrical Systems
VHS: 22h30 (TP 1h30)
Credits: 2
Coefficient: 1

Teaching Objectives:
Implement the different identification techniques studied to model or identify the internal parameters of electrical systems.

Recommended Prerequisite Knowledge:
Foundations in mathematics and control systems, proficiency with computer tools, particularly the MATLAB environment and its Simulink simulation tool.

Course Content:

TP 1: Modeling and simulation of passive and active electrical circuits using state equations and transfer functions**. (02 weeks)**
TP 2: Modeling and simulation of electromechanical converters. **(02 weeks)**
TP 3: Identification of electrical systems using input/output observations and validation of a structure (applications: electrical machine, electric furnace). **(02 weeks)**
TP 4: Direct measurement of a system's response and via SBPA generation. **(02 weeks)**
TP 5: Parametric identification of an electrical system using Strejc and Broïda methods. **(02 weeks)**
TP 6: Online numerical identification of a DC machine using the Recursive Least Squares (RLS) method. **(02 weeks)**
TP 7: Online numerical identification of an AC machine using the Recursive Least Squares (RLS) method. **(02 weeks)**

Evaluation Method:
Continuous control: **100%**

Bibliographic References:

1. I.D. Landau, "Identification des systèmes", Hermès, 1998.
2. E. Duflos, Ph. Vanheeghe, "Estimation Prédiction", Technip, 2000.
3. T. Soderstrom, P. Stoica, "System Identification", Prentice Hall, 1989.
4. R. Hanus, "Identification à l'automatique", DE Boeck, 2001.
5. L. Lennart, "System Identification: Theory for the User", Second edition, Prentice Hall 1999.
6. P. Borne, Geneviève Dauphin-Tanguy, Jean-Pierre Richard, "Modélisation et identification des processus", Technip, 1992.
7. R. Ben Abdenour, P. Borne, M. Ksouri, M. Sahli, "Identification et commande numérique des procédés industriels", Technip, 2001.
8. E. Walter, L. Pronzato, "Identification of Parametric Models from Experimental Data", Springer, 1997.
9. P.Y-C. Hwang, R.G. Brown, "Introduction to Random Signals and Applied Kalman Filtering", John Wiley and sons, **1992.**

Semester: 2
Methodologcal TU Code : TUM 1.2
Subject: TP Electrical Control Techniques
VHS: 45h00 (TP: 3h00)
Crédits: 3
Coefficient: 2

Teaching Objectives:

- Build simulation models (block diagrams) for the control of DC machines and asynchronous and synchronous AC machines in the MATLAB/Simulink environment.
- Design, in accordance with specifications, the different controllers using appropriate methods.
- Simulate the control systems for electrical machines, visualize various quantities, and evaluate performance in terms of tracking, regulation, and parametric robustness.

Recommended Prerequisite Knowledge:
Control theory of electrical machines, MATLAB/Simulink/SimPower-System software, static converters, control system design and controller synthesis, electrical machines.

Course Content:

TP 1: Open-loop control of the Asynchronous Motor–Inverter system with PWM control. **(02 weeks)**
TP 2: Scalar voltage control with converter and PWM of an asynchronous motor (Speed loop regulation). **(02 weeks)**
TP 3: Vector control of an asynchronous machine. **(03 weeks)**
TP 4: Open-loop control of the Synchronous Motor–Inverter system with PWM control. (02 weeks)
TP 5: Vector control of a synchronous machine. **(03 weeks)**
TP6: Direct Torque Control (DTC) of an asynchronous/synchronous motor. **(03 weeks)**

Evaluation Method:
Continuous control: 100%

Bibliographic References:

1. Modélisation et commande de la machine asynchrone, J.P. Caron et J.P. Hautier, Technip, 1995.
2. Control of Electrical Drives, W. Leonard, Springer-Verlag, 1996.
3. Vector control of AC machines, Peter Vas, Oxford University Press, 1990.
4. Méthodes de commande des machines électrique, R. Husson, Hermès.
5. Power Electronics and AC Drives, Prentice-Hall, B.K. Bose, 1986.
6. Modern Power Electronics and AC Drives, B-K. Bose, Prentice-Hall International Edition, 2001.
7. Actionneurs électriques, Guy Grellet et Guy Clerc, Eyrolles, 1997.
8. Commande des moteurs asynchrone, Modélisation, Contrôle vectoriel et DTC, Volume 1, C. Canudas De Wit, Edition Hermès Sciences, Lavoisier, Paris **2004**.

Semester: 2
Mthodological TU Code : TUM 1.2
Sabject:TP Sampled Control Systems and Digital control
VHS: 22h30 (TP: 1h30)
Credits: 2
Coefficient: 1

Teaching Objectives:

- Model and simulate sampled (discrete) systems;
- Understand sampling and signal reconstruction;
- Verify the dynamic behavior of sampled (discrete) systems;
- Simulate and implement digital controllers such as PID, RST, and state-feedback controllers.

Recommended Prerequisite Knowledge:
Ability to use simulation and programming software. Signal processing and control of continuous linear systems.

Course Content:

TP 1: Simulation of sampling and reconstruction operations. **(02 weeks)**
TP 2: Time and frequency analysis of basic sampled systems. **(02 weeks)**
TP3: Control of electrical systems using digital PI/PID controllers. **(02 weeks)**
TP 4: Control of electrical systems using digital phase-lead/phase-lag controllers. **(02 weeks)**
TP 5: Digital RST control: Case study. (03 weeks)
TP 6: Digital state-feedback control: Application to electrical systems. **(02 weeks)**
TP 7: Implementation of a digital control system for an electrical system. **(02 weeks)**

Evaluation Method:
Continuous control: **100%**

Bibliographic References:

1. J.R. Ragazzini, G. F. Franklin, Les systèmes asservis échantillonnés , Dunod, 1962.
2. Daniel Viault, Y. Quenec'hdu, Systèmes asservis échantillonnés , ESE, 1977.
3. E. Godoy, E. Ostertag, Commande numérique des systèmes : Approches fréquentielle et polynomiale, Ellipses Marketing ,2004.
4. H. Buhler, Réglages échantillonnés (T1 et T2), PPR.
5. E. Godoy, Régulation industrielle, Dunod.
6. K. J. Astrom et B. Wittenmark, Computer controlled systems, Prentice Hall

Semester: 2
Mthodological TU Code : TUM 1.2
Subject: Fault Diagnosis in Control Systems VHS: 22h30 (TP: 1h30)
Credits: 2
Coefficient: 1

Teaching Objectives:
Implement the various knowledge acquired in the course for diagnosing failures in electrical control systems to prevent malfunctions and improve system reliability and service continuity.

Recommended Prerequisite Knowledge:
Electrical circuits, DC and AC electrical machines, signal theory, numerical analysis.

Course Content:

TP 1: Failure diagnosis tools for continuous monitoring of an electrical control system. **(03 weeks)**
TP2: Diagnosis of control and power equipment. **(03 weeks)**
TP 3: Vibration analysis of rotating machines with preparation of a technical sheet for maintenance purposes. **(03 weeks)**
TP 4: Lubricant analysis of rotating machines with preparation of a technical sheet for maintenance purposes. **(03 weeks)**
TP 5: Application of intelligent fault diagnosis techniques for multi-symptom and multi-cause cases. **(03 weeks)**

Evaluation Method:
Continuous control: 100%

Bibliographic References:

1. J. Montmain, J. Ragot, D. Sauter, Supervision des procédés complexes, Lavoisier, 2007.
2. L. Ljung, Systems Identification: theory for the User. Prentice-Hall, 2nd edition, 1999.
3. P.S.R. Murty, Power System Analysis, BS Publications, 2007.
4. D. Brown, D. Harrold, R. Hope, Control System Power and Grounding Better Practice, Elsevier, 2004.
5. G. Cullman, Eléments de calcul informationnel, Bibliothèque de l'ingénieur électricien-mécanicien. Ed. Albin Michel.
6. J.D. Glover, M.S. Sama, T.J. Overbye, "Power Systems Analysis and Design", 4th Edition, Thompson-Engineering.

Semester : 2
Transversal TU: TUT 1.2
Sabject : Compliance with Ethical and Integrity Standards
VHS : 22h30 (Course : 1h30)
Credit : 1
Coefficient : 1

Teaching Objectives:

Develop students' awareness of ethical principles and rules governing university life and the professional world. Raise awareness about respecting and valuing intellectual property. Explain the risks of moral wrongs such as corruption and ways to combat them. Alert students to the ethical challenges posed by new technologies and sustainable development.

Recommended Prerequisite Knowledge:
Ethics and professional conduct (fundamentals)

Course Content:

A. Respect for Ethics and Integrity

1. **Review of the Ethics and Professional Conduct Charter of the MESRS:**
   Integrity and honesty, academic freedom, mutual respect, scientific truth requirement, objectivity and critical thinking, fairness, rights and obligations of students, teachers, and administrative/technical staff.
2. **Responsible and Integrity-Based Research:**

- Respecting ethical principles in teaching and research.
- Responsibilities in teamwork: professional equality, anti-discrimination practices, pursuit of public interest, inappropriate behaviors in collective work.
- Adopting responsible conduct and combating misconduct: responsible research conduct, scientific fraud, anti-fraud practices, plagiarism (definition, forms, procedures to avoid unintentional plagiarism, detection, sanctions), falsification and fabrication of data.

3. **Ethics and Professional Conduct in the Workplace:**
   Legal confidentiality in companies, loyalty to the company, responsibility within the organization, conflict of interest, integrity (corruption in the workplace, forms, consequences, prevention methods, sanctions).

B. Intellectual Property

I. Fundamentals of Intellectual Property:

1. Industrial property, literary and artistic property.
2. Rules for citing references (books, scientific articles, conference communications, theses, dissertations, etc.).

II. Copyright:

1. Copyright in the digital environment: introduction, copyright for databases and software, specific cases of open-source software.

2. Copyright on the Internet and in e-commerce: domain name rights, intellectual property on the Internet, e-commerce site rights, intellectual property and social networks.
3. Patents: definition, patent rights, purpose of patents, patentability, patent application process in Algeria and worldwide.

III. Protection and Valorization of Intellectual Property:
How to protect intellectual property, rights violations and legal tools, valorization of intellectual property, protection of intellectual property in Algeria.

C. Ethics, Sustainable Development, and New Technologies:
Connection between ethics and sustainable development, energy efficiency, bioethics, and emerging technologies (artificial intelligence, scientific progress, humanoids, robots, drones).

Evaluation Method:
Exam: **100%**

Bibliographic References:

1. Charte d'éthique et de déontologie universitaires, https://www.mesrs.dz/documents/12221/26200/Charte+fran__ais+d__f.pdf/50d6de61-aabd-4829-84b3-8302b790bdce
2. Arrêtés N°933 du 28 Juillet 2016 fixant les règles relatives à la prévention et la lutte contre le plagiat
3. L'abc du droit d'auteur, organisation des nations unies pour l'éducation, la science et la culture(UNESCO)
4. E. Prairat, De la déontologie enseignante. Paris, PUF, 2009.
5. Racine L., Legault G. A., Bégin, L., Éthique et ingénierie, Montréal, McGraw Hill, 1991.
6. Siroux, D., Déontologie : Dictionnaire d'éthique et de philosophie morale, Paris, Quadrige, 2004, p. 474-477.
7. Medina Y., La déontologie, ce qui va changer dans l'entreprise, éditions d'Organisation, 2003.
8. Didier Ch., Penser l'éthique des ingénieurs, Presses Universitaires de France, 2008.
9. Gavarini L. et Ottavi D., Éditorial. de l'éthique professionnelle en formation et en recherche, Recherche et formation, 52 | 2006, 5-11.
10. Caré C., Morale, éthique, déontologie. Administration et éducation, 2e trimestre 2002, n°94.
11. Jacquet-Francillon, François. Notion : déontologie professionnelle. Le télémaque, mai 2000, n° 17
12. Carr, D. Professionalism and Ethics in Teaching. New York, NY Routledge. 2000.
13. Galloux, J.C., Droit de la propriété industrielle. Dalloz 2003.
14. Wagret F. et J-M., Brevet d'invention, marques et propriété industrielle. PUF 2001
15. Dekermadec, Y., Innover grâce au brevet: une révolution avec internet. Insep 1999
16. AEUTBM. L'ingénieur au cœur de l'innovation. Université de technologie Belfort-Montbéliard
17. Fanny Rinck etléda Mansour, littératie à l'ère du numérique : le copier-coller chez les étudiants, Université grenoble 3 et Université paris-Ouest Nanterre la défense Nanterre, France
18. Didier DUGUEST IEMN, Citer ses sources, IAE Nantes 2008
19. Les logiciels de détection de similitudes : une solution au plagiat électronique? Rapport du Groupe de travail sur le plagiat électronique présenté au Sous-comité sur la pédagogie et les TIC de la CREPUQ
20. EmanuelaChiriac, Monique Filiatrault et André Régimbald, Guide de l'étudiant: l'intégrité intellectuelle plagiat, tricherie et fraude… les éviter et, surtout, comment bien citer ses sources, 2014.
21. Publication de l'université de Montréal, Stratégies de prévention du plagiat, Intégrité, fraude et plagiat, 2010.
22. Pierrick Malissard, La propriété intellectuelle : origine et évolution, 2010.
23. Le site de l'Organisation Mondiale de la Propriété Intellectuelle www.wipo.int
24. http://www.app.asso.**fr**/

Semestre: S2
Unité d'enseignement:1.2.1
Matière : Elements of applied artificial intelligence
VHS: 45h00 (Course1h30, TP 1h30)
Credits:2
Coefficient:2

Target Skills:

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

Objectives:

- Master AI algorithms.
- Introduction to the fundamental concepts, tools, and applications of modern artificial intelligence, with a focus on practical implementation using Python and its libraries.
- Deepen Python programming skills.
- Understand AI approaches in problem-solving.

Prerequisites:
Advanced Python programming

Required Equipment:

- A computer with Python installed.
- Python libraries: NumPy, Pandas, Scikit-learn, Matplotlib, os.listdir, os.path.exists, os.mkdir, os.rmdir, Seaborn, Plotly, Requests, BeautifulSoup, Tkinter, PyQT, etc.
- TensorFlow, PyTorch, etc.

Course Content:

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

1. Definitions and application areas of AI.
2. Historical evolution of AI.
3. Introduction to major domains:
    - Machine Learning
    - Deep Learning

Chapter 2: Basic Mathematics for AI (1 week)

1. Linear algebra: vectors, matrices, products, norms.
2. Probability & statistics:
    - Variables, expectation, variance.
    - Common distributions: normal, binomial, uniform.
3. Simple linear regression:
    - Formulation, cost, optimization.
    - Implementation with Scikit-learn.
4. Exercises:

- Matrix operations with NumPy.
- Linear regression using a Python library (e.g., Scikit-learn).
- Introduction to Matplotlib for visualization.

Chapter 3: Machine Learning (3 weeks)

1. Key concepts: data, models, features, labels, generalization.
2. Phases of a learning pipeline: training, validation, testing.
3. Types of learning:
   - Supervised
   - Unsupervised
   - Reinforcement (overview)
4. Exercises: deepen concepts covered in class.

Chapter 4: Supervised Classification (3 weeks)

1. Principles of training a simple classification model.
2. Models and algorithms:
   - Support Vector Machine (SVM)
   - Decision Trees
3. Performance evaluation:
   - Confusion matrix, precision, recall, F1-score.
4. Exercises:
   - Using Scikit-learn for model training.
   - Comparing multiple models on a dataset.

Chapter 5: Unsupervised Learning (Clustering)

1. Concept of clustering.
2. Algorithms:
   - K-means
   - DBSCAN (Density-Based Spatial Clustering of Applications with Noise)
3. 2D visualization and interpretation of results.
4. Exercises:
   - Apply clustering algorithms on a dataset.
   - Visualize clusters.

Chapter 6: Neural Networks

1. Neural network architecture:
   - Perceptron, layers (including hidden layers), weights, biases.
   - Activation functions: ReLU, Sigmoid, Softmax, etc.
   - Application exercises.
2. Introduction to Deep Learning:
   - Concept of deep layers.
   - Introduction to convolutional neural networks (CNNs).
3. Exercises:
   - Introduction to TensorFlow and PyTorch.
   - Analyze datasets (text/images) and predict outcomes (e.g., sentiment analysis).

Chapter 7: Mini Project (Guided personal work outside class)
Create a complete classification or clustering model, including preprocessing, training, and visualization. Choose a project to implement from start to finish, examples include:

- Handwritten character recognition
- Natural disaster prediction
- Developing a chatbot to answer common company questions
- Detecting abnormal sounds in machines (defective bearings, excessive vibration)
- Sentiment analysis of social media posts about a product, brand, or event

Practical Work (Lab Sessions):

- **TP 01:** Python initialization
- **TP 02:** Implement simple regression with Scikit-learn and visualize with Matplotlib
- **TP 03:** ML pipeline and data splitting, reinforce course concepts
- **TP 04:** Train a simple classification model using Scikit-learn
- **TP 05:** Implement clustering algorithms (K-means, DBSCAN) and visualize clusters
- **TP 06:** Build a simple neural network using TensorFlow, PyTorch, or Keras; implement a basic CNN for image classification (e.g., MNIST dataset)

Evaluation:
Exam: **60%**, Continuous control: **40%**

Bibliography:
(To be provided by instructor)

- Ganascia, J.Gabriel (2024) : l'IA expliquée aux humains. Paris France- Edition le Seuil.
- Anglais, Lise, Dilhac, Antione, Dratwa, Jim et al. (2023) : L'éthique au coeur de l'IA. Quebec Obvia.
- J.Robert (2024) : Natural LanguageProcessing (NLP) : définition et principes – Datasciences. Lien : https://datascientest.com/introduction-au-nlp-natural-language-processing
- Qu'est-ce que le traitement du langage naturel. Lien : https://aws.amazon.com/fr/what-is/nlp/
- M.Journe : Eléments de Mathématiques discrètes – Ellipses
- F.Challet : L'apprentisage profond avec Python – Eyrolles
- H.Bersini (2024) : L'intelligence artificielle en pratique avec Python – Eyrolles
- B.Prieur (2024) : Traitement automatique du langage naturel avec Python – Eyrolles
- V.Mathivet(2024) : Implémentation en Python avec Scikit-learn – Eyrolles
- G.Dubertret (2023) : Initiation à la cryptographie avec Python – Eyrolles
- S.Chazallet (2023) : Python 3 – Les fondamentaux du langage - Eyrolles
- H.Belhadef, I.Djemal : Méthode TALN – Cours de l'unievrsité de Msila - Algérie

V - Detailed Program by Subject for Semester S3

Semester : 3
Fundamental TU Code : TUF 2.1.1
Subject: Nonlinear and Advanced Control
VHS: 67h30h (Course: 3h,TD :1h30)
Credits:6
Coefficient:3

Teaching Objectives:
Understand the different approaches for modeling and controlling nonlinear systems. Learn the principles of optimal control, adaptive control, and sliding mode control, and distinguish them from other control methods. Perform synthesis of optimal, adaptive, and sliding mode controllers. Know the conditions for their application and apply these control methods to industrial processes that require them.

Recommended Prerequisite Knowledge:

- Continuous linear system control
- State-space modeling and control
- Mathematical tools (ordinary differential equations, derivatives, Lie brackets)
- System control and optimization

Course Content:

Chapter 1: Basic Concepts of Nonlinear Systems (3 weeks)
1.1. Overview of nonlinear systems, common nonlinearities, and state-space modeling of nonlinear systems
1.2. Complex interconnected nonlinear systems, singular disturbances
1.3. Piecewise-linear systems and multi-models

Chapter 2: Stability and Control of Nonlinear Systems (3 weeks)
2.1. Stability, Lyapunov stability
2.2. State feedback linearization control: input/state linearization
2.3. State feedback linearization control: input/output linearization

Chapter 3: Optimal Control (3 weeks)
3.1. Formulation of the control problem
3.2. Optimal control of systems without inequality constraints
  3.2.1. Optimal control of nonlinear, non-stationary systems
  3.2.2. Optimal control of linear, non-stationary systems with quadratic criterion
  3.2.3. Optimal control of linear, stationary systems with quadratic criterion (LQ)
  3.2.4. Optimal control of linear, stationary systems with quadratic criterion (LQG)

Chapter 4: Adaptive Control (3 weeks)
4.1. Principle of adaptive control
4.2. Different adaptive control techniques
4.3. Synthesis of adaptive control laws
  4.3.1. Direct adaptive control with reference model
  4.3.2. Indirect self-tuning adaptive control
  4.3.3. Self-tuning adaptive control with predictor reparameterization

Chapter 5: Advanced Control Techniques (3 weeks)
5.1. Sliding mode control
5.2. Backstepping control
5.3. Passivity-based control

Evaluation Method:
Continuous control: **40%**; Exam: **60%**

Bibliographic References:

1. M. Vidyasagar, Nonlinear system analysis, Prentice Hall
2. A. Isidori, Nonlinear control systems (I et II), Springer-Verlag
3. H. K. Khalil, Nonlinear Systems, Prentice Hall
4. H. Nijmeijer, Nonlinear dynamical control systems
5. D. Alazar, « Robustesse et commande optimale ». Masson 1990
6. R. Boudarel et al., « Commande optimale des processus ». Masson 1989
7. J-P. Babary et W. Pelczewski, « Commande optimale des systèmes continus déterministes ». Masson 1985
8. S. N. Desineni, « Optimal control system ». CRC Press 2003
9. R. Lozano et D. Taoutaou, « Commande adaptative et applications ». Paris : Hermès Science Publications, 2001
10. P. Naslin, 'Theorie de la commande et conduite optimale, Dunod 1969
11. J-P. Babary et W. Pelczewski, « Commande optimale des systèmes continus déterministes ». Masson 1985.
11. K. Astrom, B.Wittenmak, 'Adaptive Control' Lund Instituite of Technology, Addison Wisly Publishing Company 1989
12. Grellet, 'Actionneurs électrques' Eyrolles, 1999
13. J. Levine, ' Introduction à la commande non linéaire' Centre Automatique et Systèmes. Ecole des mines de paris
14. J. Levine, 'Analyse et commande des Systèmes non Linéaires', Centre Automatique et Systèmes. Ecole des mines de paris
15. NadjibBennis, ' Représentation d'état des systèmes linéaires continus, commande par placement des poles',
*16. www.specialautom.**net***

Semester: 3
Fundamental TU Code TUF : 2.1.1
Subject: Programmable Logic Controllers
VHS: 22h30(Course: 1h30)
Credits: 2
Coefficient: 1

Teaching Objectives:
The course aims first to develop the skills necessary to design (both hardware and software) an automation solution based on a PLC (Programmable Logic Controller), and then to deepen knowledge to design and implement digital control (for example, speed regulation of a motor). Students will also study various industrial applications, explore more or less complex forms of GRAFCET, and be introduced to industrial networks.

Recommended Prerequisite Knowledge:
Combinational and sequential logic, programming, microprocessors.

Course Content:

Chapter 1: General Architecture of a PLC
- Hardware description of the Simatic S7 (e.g., S7-200/CPU216)
- I/O modules, cycle concept, data types, addressing modes

Chapter 2: Basic Instruction Set (Step 7 Language)
- Logic stack, Boolean instructions
- Transfer instructions
- Arithmetic and logical instructions

Chapter 3: Timers (Identification and Programming)
Chapter 4: Interrupts
- Program organization in Step 7
- S7 events (e.g., S7-200)
- Handling interrupt events and programming

Chapter 5: Analog I/Os (Identification and Programming)
Chapter 6: PID Control Loops (Identification and Programming)
Chapter 7: Industrial Networks
- General architecture
- Communication protocols
- Applications

Evaluation Method:
Exam: **100%**

Bibliographic References:

1. Micro System SIMATIC S7-200 One Hour Primer, Siemens AG 1999
2. Micro System SIMATIC S7-200 Two Hour Primer, Siemens AG 2000
3. SIMATIC S7-200 Programmable Controller System Manual, Siemens AG 1998
4. E. Godoy, Régulation industrielle: Outils de modélisation, méthodes et architectures de commande, 2e édition. Paris: Dunod, 2014.
5. K. Kamel and E. Kamel, Programmable Logic Controllers: Industrial Control. New York: McGraw-Hill Professional, 2013.
6. W. Bolton, Les automates programmables industriels. Paris: Dunod, 2010.
7. J. Stenerson, Programmable Logic Controllers with Controllogix, International Edition. Clifton Park, N.Y: Broadman & Holman Publishers, 2009.

8. S. Moreno and E. Peulot, Le Grafcet : Conception-Implantation dans les automates programmablesindustriels. Saint-Quentin-en-Yvelines: Casteilla, 2009.
9. F. P. Miller, A. F. Vandome, and J. McBrewster, Automate Programmable Industriel: Programmation informatique, Automatique, Industrie, Programme (informatique), Interrupteur, Automaticien. AlphascriptPublishing, **2010**.

Semester: 3
Fundamental TU Code : TUF2.1.2
Subject: Artificial Intelligence Techniques
VHS: 45h (Course: 1h30,TD :1h30)
Credits: 4
Coefficient: 2

Teaching Objectives:
Enable students to become familiar with artificial intelligence techniques applied to the control and optimization of systems.
Recommended Prerequisite Knowledge:
Dynamic systems, basic mathematical analysis, fundamentals of optimization, and probability concepts.
Course Content:
Chapter 1: Fuzzy Logic (02 weeks)
- General fundamentals
- Fuzzy sets
- Linguistic variables
- Membership functions
- Fuzzy logic operators
- General structure of a fuzzy controller: fuzzification, inference engine or decision block, inference methods, defuzzification

Chapter 2: Neural Networks (03 weeks)
- Neural network topology
- Layered networks
- Static networks
- Dynamic neural networks
- Neural network learning: supervised and unsupervised learning

Chapter 3: Neuro-Fuzzy Networks (02 weeks)
Chapter 4: Genetic Algorithms (02 weeks)
Chapter 5: Particle Swarm Optimization Techniques (02 weeks)
Chapter 6: Expert Systems (02 weeks)
Chapter 7: Probability and Probabilistic Reasoning (02 weeks)
Evalutaion Method:
Continuous control: **40%**; Exam: **60%**
Bibliographic References:

1. P. A. Bisgambiglia, La logique floue et ses applications, Hermès-science
2. H. Buhler, Commande par logique floue, PPR
3. HeikkiKoivo, Soft computing
4. D. R. Hush & B.G. Horne,*"Progress in Supervised Learning Neural Networks,"* IEEE signal proc. magazine, Vol.10, No.1, pp.8-39, Jan. 1993.
5. B. Kosko, *" Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence,"* Englewood Cliffs, Nj: Prentice-Hall, 1992.
6. L.X.Wang, "*Adaptive Fuzzy Systems & Control: Design & Stability Analysis*": Prentice-Hall, 1994.
7. David E. Goldberg, *Algorithmes Génétiques,* Edit. Addison Wesley, 1994.
8. *HansruedIBühler, « Réglage par logique floue »*
9. *Pierre-yvesGlorennec, « Algorithmes d'apprentissage pour systèmes d'inférence floue »*
10. *P. Borne, J. Rozinoer, J.-Y. Dieulot, L. Dubois, « Introduction à la commande floue »*
11. *Bernadette Bouchon-Meunier, Laurent FOULLOY, MOHAMMED RAMDANI, « Logique floue. Exercices corrigés et exemples d'applications »*

12. *BERNADETTE BOUCHON-MEUNIER, « La logique floue et ses applications »*
13. *Hung T. NGUYENNADIPURAM R. PRASAD, CAROL L. WALKER • ELBERT A. WALKER,« A First Course in Fuzzy and Neural Control »*
14. *FAKHREDDINE O. KARRAY, CLARENCE DE SILVA, « Soft computing and intelligent systems design. Theory, tools and applications »*
15. *PIERRE. BORNE, MOHAMED BENREJEB, JOSEPH HAGGÈGE, « Les réseaux de neurones. Présentation et applications »*
16. *BEGHDADI HADJ ALI, SENOUCI MOHAMED, « Réseaux de neurones : Théorie et pratique »*
17. *G. DREYFUS, J. –M. MARTINEZ, M. SAMUELIDES, M. B. GORDON, F. BADRAN, S. THIRIA, L. HERAULT, « Réseaux de neurones. Méthodologie et applications »*
18. *LÉON PERSONNAZ,ISABELLE RIVALS, « Réseaux de neurones formels pour la modélisation, la commande et la classification »*
19. *CHRISTINE SOLNON, « Optimisation par colonies de fourmis »*
20. *NICOLAS MONMARCHÉ, FRÉDÉRIC GUINAND, PATRICK SIARRY « Fourmisartificielles 1. Des bases de l'optimisation aux applications industrielles »*
21. *STUART RUSSELL, PETER NORVIG, « Intelligence artificielle, avec plus de 500 exercices »*
22. *JOHANN DRÉO, ALAIN PÉTROWSKI, PATRICK SIARRY, ÉRIC TAILLARD, « Métaheuristiques pour l'optimisation difficile : Recuit simulé, recherche avec tabous, algorithmes évolutionnaires et algorithmes génétiques, colonies de fourmis … »*
23. *PATRICK SIARRY ET ALL, « Métaheuristiques : Recuit simulé, recherche avec tabous, recherche à voisinages variables, méthodes GRASP, algorithmes évolutionnaires, fourmis artificielles, essaims particulaires et autres méthodes d'optimisation »*

Semester: 3
Fundamental TU Code : TUF 2.1.2
Subject : Electrical Control of Industrial Mechanisms
VHS:67h30 (Course: 3h00, TD 1H30)
Credits: 6
Coefficient: 3

Teaching Objectives:
Prepare students for better integration into industry by presenting various industrial mechanisms and the appropriate control techniques.

Recommended Prerequisite Knowledge:
Basic control principles, electromechanical systems

Course Content:

Chapter 1: Criteria for Selecting an Electric Motor in an Industrial Environment (02 weeks)

1.1 Electric Motors:

- Motors for overhead cranes, special-purpose motors, use of standard construction electric machines
  1.2 Motor Selection:
- Based on power and operating speed

Chapter 2: Electrical Control and Automation of Pumps, Fans, and Compressors (03 weeks)

- General principles
- Power at the shaft end
- Starting mechanisms for fan loads
- Electrical control of fans
- General recommendations for selecting electrical control for pumps, fans, and compressors

Chapter 3: Power Supply and Automation of Elevators and Extractors (02 weeks)

- General principles
- Precision in positioning of lifting systems
- Requirements for elevator control systems
- Typical control schematics for elevators
- Automation of elevator speed control

Chapter 4: Automation of Overhead Cranes (02 weeks)

- General principles
- Motor loads for crane mechanisms
- Electromagnetic lifting systems
- Electrical control systems of overhead cranes
- Requirements for mechanical characteristics of crane controls
- Automation of overhead cranes using thyristor converters
- Equipment of large cranes
- Remote control of overhead cranes
- Power supply for cranes

Chapter 5: Power Supply and Automation of Continuous Transport Mechanisms (03 weeks)

- General principles
- Selection of conveyor control
- Synchronization of multiple conveyor motors
- Electrical control of transport systems
- Power supply and automation of cable cars and passenger transport machines: escalators, multi-cabin elevators, rotary excavators

Chapter 6: Mini-Projects (03 weeks)

- Case studies on: excavators, rolling mills, electric furnaces, welding equipment, electrolysis and metal coating, metallurgical plants, chemical industry, oil drilling stations, paper and pulp industry, cement industry, glass and metal industry, etc.

Evaluation Method:
Continuous control: **40%**; Exam: **60%**

Semester: 3
Methodological TU Code : TUM 2.1
Subject : TP Nonlinear and Advanced Control
VHS:22h30 (TP: 3H00)
Credits:4
Coefficient:2

Teaching Objectives:
Enable students to acquire all the necessary tools to program, simulate, validate, and implement various approaches for modeling and controlling nonlinear systems, as well as to validate optimal and adaptive control strategies and other advanced techniques such as Sliding Mode, Backstepping, or Passivity via simulation. Then, implement these strategies on a test bench equipped with a DsPACE control board and acquisition cards.

Recommended Prerequisite Knowledge:
System control and optimization, programming, and proficiency in using programming and dynamic system simulation software (Matlab).

Course Content:

TP 1: Common nonlinear systems, complex interconnected systems, singular disturbances. **(02 weeks)**
TP 2: Regulation via linearizing state feedback; input/output linearization. **(02 weeks)**
TP 3: Simulation validation with Matlab of an optimal control without constraints for a DC motor, followed by validation on a test bench equipped with DsPACE. **(02 weeks)**
TP 4: Simulation validation with Matlab of a direct adaptive control with reference model for a DC motor, followed by validation on a DsPACE-equipped test bench. **(02 weeks)**
TP 5: Simulation validation with Matlab of a sliding mode control for a DC motor, followed by validation on a DsPACE-equipped test bench. **(02 weeks)**
TP 6: Simulation validation with Matlab of a Backstepping control. **(02 weeks)**
TP 7: Simulation validation with Matlab of a control based on passivity. **(02 weeks)**

Evaluation Method:
Continuous control: **100%**

References:

1. R. Lozano et D. Taoutaou, « Commande adaptative et applications ». Paris : Hermès Science Publications, 2001.
2. D. Alazar, « Robustesse et commande optimale ». Masson 1990.
3. R. Boudarel et al., « Commande optimale des processus ». Masson 1989.
4. J-P. Babary et W. Pelczewski, « Commande optimale des systèmes continus déterministes ». Masson 1985.
5. S. N. Desineni, « Optimal control system ». CRC Press 2003.
6. V.I. Utkin, «Sliding mode and their application in variable structure system". Mir, Moscou 1978.
7. H. Buhler, « Réglage par mode de glissement ». Presse polytechnique romandes, Lausanne, 1983.
8. M. Vidyasagar, Nonlinear system analysis, Prentice Hall
9. A. Isidori, Nonlinear control systems (I et II), Springer-Verlag
10. H. K. Khalil, NonlinearSystems, Prentice Hall
11. H. Nijmeijer, Nonlineardynamical control systems
12. J. Levin, Analysis and control of nonlinearsystems

Semester: 3
Méthodological TU Code : TUM 2.1
Subject: TP Artificial Intelligence Techniques / TP: Real-Time Digital Control Implementation
VHS:22h30 (TP : 1H30)
Credits: 2
Coefficient: 1

Teaching Objectives:
Program and simulate control laws based on artificial intelligence techniques.
Understand how to implement a real-time digital control system.

Recommended Prerequisite Knowledge:
Simulation and programming software, dynamic systems, optimization, logic, and probability.

Course Content:

TP – Artificial Intelligence Techniques

- **TP 1:** Introduction to fuzzy logic. **(01 week)**
- **TP 2:** Artificial neural networks**. (01 week)**
- **TP 3:** Adaptive networks and neuro-fuzzy networks. **(01 week)**
- **TP 4:** Genetic algorithms. **(02 weeks)**
- **TP 5:** Particle Swarm Optimization (PSO). **(01 week)**
- **TP 6:** Expert systems and probabilistic reasoning. **(02 weeks)**

TP – Real-Time Digital Control Implementation

- **TP 1:** Modeling and implementation of an Analog-to-Digital Converter (ADC) using Matlab. **(01 week)**
- **TP 2:** Modeling and implementation of a Digital-to-Analog Converter (DAC) using Matlab. **(01 week)**
- **TP 3:** Speed regulation of a DC motor using digital PID control. **(01 week)**
- **TP 4:** Implementation of PWM techniques on a digital processor. **(02 weeks)**
- **TP 5:** Computer-based control of an electric motor. **(02 weeks)**

Evaluation Method:
Continuous control: **100%**

References:

1. P. A. Bisgambiglia, La logique floue et ses applications, Hermès-science
2. H. Buhler, Commande par logique floue, PPR
3. HeikkiKoivo, Soft computing
4. D. R. Hush & B.G. Horne,*"Progress in Supervised Learning Neural Networks,"* IEEE signal proc. magazine, Vol.10, No.1, pp.8-39, Jan. 1993.
5. B. Kosko, *" Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence,"* Englewood Cliffs, Nj: Prentice-Hall, 1992.
6. L.X.Wang, "*Adaptive Fuzzy Systems & Control: Design & Stability Analysis*": Prentice-Hall, 1994.
7. David E. Goldberg, *Algorithmes Génétiques,* Edit. Addison Wesley, **1994.**

Semester: 3
Methodological TU Code : TUM 2.1
Subject TP: Electrical Control of Industrial Mechanisms VHS:22h30 (TP : 1H30)
Credits: 2
Coefficient: 1

Teaching Objectives:
Gain practical experience with real-world control examples.

Recommended Prerequisite Knowledge:
Control techniques, electromechanical systems.

Course Content:

TP 1: Automatic barrier (02 weeks)

TP 2: Drilling system (02 weeks)

TP 3: Soap marking system (02 weeks)

TP 4: Door control system (03 weeks)

TP 5: Hoist/lift system (03 weeks)

TP 6: Brick sorting system (03 weeks)

Evaluation Method:
Continuous control: **100%**

References:

Brochures des TP**s**

Semester: 3
Méthodological TU Code : TUM 2.1
Subject : TP Industrial Programmable Logic Controllers
VHS:22h30 (TP : 1H30)
Credits: 1
Coefficient: 1

Teaching Objectives:
Teach students how to install, program, and use a PLC (Programmable Logic Controller). Introduce them to mastering program editing, debugging, and correcting detected errors.
Synthesize, simulate, and implement PLC-based systems (logical automation, control loops, and industrial networks).

Recommended Prerequisite Knowledge:
Combinational and sequential logic, PLCs, GRAFCET, Step7, Simatic S7.

Course Content:

TP 1: Logical automation: pneumatic cylinder system

TP 2: Logical automation: systems with various logical processes (motors, cylinders, etc.), with direct or timed actions, including emergency events (handling interrupts)

TP 3: Control loop: implementation, simulation, and/or realization of a control system for an electric motor

TP 4: Industrial network: implementation and utilization of an industrial network

Note:
The above labs can be performed on software platforms (TIA Portal) or experimentally on a test bench based on a Simatic S7-? (e.g., S7-200) with scaled-down processes (small motors, small cylinders), displays, tachometers, buttons, etc.

Evaluation Method:
Continuous control: **100%**

References

1. Micro System SIMATIC S7-200 One Hour Primer, Siemens AG 1999
2. Micro System SIMATIC S7-200 Two Hour Primer, Siemens AG 2000
3. SIMATIC S7-200 Programmable Controller System Manual, Siemens AG 1998
4. J. A. Rehg and G. J. Sartori, *Programmable Logic Controllers*, 2nd ed. Upper Saddle River, N.J: Prentice Hall, 2008.
5. E. P. Adrover, *Introduction to PLCs: A beginner's guide to Programmable Logic Controllers*. San Bernardino, CA: Elvin Perez Adrover, 2012.
6. J. R. Hackworth and F. D. H. Jr, *Programmable Logic Controllers: Programming Methods and Applications*, 1st ed. Upper Saddle River, N.J: Prentice Hall, 2003.
7. G. Barton, *programmable logic controller 139 Success Secrets - 139 Most Asked Questions On programmable logic controller - What You Need To Know*. Emereo Publishing, 2014.
8. R. J. Tocci, N. Widmer, and G. Moss, *Digital Systems: Principles and Applications: International Edition*, 11th ed. Boston, Mass.: Pearson, **2010**.

Semester: 3
Transversal TU Code: TUT 2.1
Subject 1 : Reverse Engineering
VHS: 45h00 (Course : 1h30 et Atelier : 1h30)
Credits: 2
Coefficient: 2

Teaching Objectives:

- Understand the principles and goals of Reverse Engineering (RE) in science and technology (ST).
- Get introduced to the tools and methods of RE in the relevant specialty.
- Appreciate the value and ethical principles of RE in design, manufacturing, and product quality assurance.
- Encourage critical thinking, technical curiosity, reasoned reverse engineering, and innovation.
- Learn to analyze, document, and model an existing system without initial documentation.

Targeted Competencies:

- Decompose and analyze an existing system.
- Faithfully reproduce a technical schematic or 3D model from an existing product.
- Apply diagnostic and simulation tools.
- Work in groups on exploratory projects.
- Identify the legal limits of reverse engineering.

Prerequisites:
Fundamental knowledge in the relevant specialty.

Course Content:

1. Introduction to Reverse Engineering

- History, legal and ethical issues of RE.
- Definitions and application areas: approaches (hardware, software, processes…).
- Domains: 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. Hardware Reverse Engineering

- Electrical devices / PCBs: visual inspection, component identification.
- Use of tools: multimeter, oscilloscope, logic analyzer.
- Recognizing electrical schematics.
- Reconstruction of schematics using KiCad / Fritzing / Proteus / EPLAN Electric P8 / QElectroTech.

4. Software Reverse Engineering

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

5. Mechanical Reverse Engineering

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

6. Security and Intrusion Detection

- RE in cybersecurity: malware detection, vulnerability analysis.
- Software signatures, RE protections (obfuscation, encryption).

7. Real Case Studies

- Analysis of obsolete or unknown products (mouse, power supply, Bluetooth module, etc.).
- Example of reverse engineering a mechanical part or simple system (fan, enclosure).

Lab Examples (based on four engineering fields):

Electrical Engineering:

- Reverse-engineer an electrical device without a schematic (e.g., time relay, electrical cabinet, speed drive, electric machine, automation system).
- Objectives: understand operation, draw schematics, propose improved variants.
- Component identification (ICs, transistors, resistors, capacitors, etc.).
- Use of tools: multimeter, oscilloscope, logic analyzer.
- Firmware reading and extraction from microcontrollers.
- Introduction to electronic counterfeit detection.

Mechanical Engineering:

- Reverse-engineer a simple mechanism (e.g., manual pump, torque wrench, mini-press).
- Mechanical disassembly (pump, gears, cylinder…).
- Measurement and reconstruction of plans or 3D models using CAD software (SolidWorks, Fusion360).
- Material identification and manufacturing methods.
- Functional simulation from the recreated model.

Civil Engineering:

- Analyze existing structures without plans (walls, slabs, structures…).
- Examples: metal staircase, window support, formwork.
- Study and reverse-engineer an existing structural element.
- Identify materials, joints, and stresses.
- Model the structure using Revit, AutoCAD, or SketchUp.
- Study rehabilitation or reproduction of old structural elements.

Process Engineering:

- Reverse-engineer a laboratory module (e.g., instruments, distillation, filtration, heat exchanger, simple reactor).
- Analyze existing industrial systems (distillation column, exchanger, reactor…).
- Reconstruct PFD and PID diagrams from observation of a facility.
- Identify sensors, actuators, and control elements.
- Study material/energy flows in a process.

Assessment Method:

- Practical labs (TP).
- Mini reverse-engineering project (report + presentation).
- Final exam (MCQs + case study).
- Exam: 60%; Labs/Project: 40%.

References:

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

Semester : 3
Transversal TU Code: TUT 2.1
Subject : Research and Thesis Design
VHS : 22h30 (Course: 1h30)
Credits : 1
Coefficient : 1

Teaching Objectives:
Provide students with the necessary tools to search for useful information and effectively use it in their final year project. Guide them through the stages leading to the writing of a scientific document. Emphasize the importance of communication and teach students to present their work rigorously and pedagogically.

Recommended Prerequisites:
Knowledge of writing methodology and presentation techniques.

Course Content:

Part I – Literature Research:

Chapter I-1: Defining the Topic (2 weeks)

- Title of the topic
- List of keywords related to the topic
- Collect basic information (acquire specialized vocabulary, meanings of terms, linguistic definitions)
- Information to be researched
- Assess current knowledge in the field

Chapter I-2: Selecting Information Sources (2 weeks)

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

Chapter I-3: Locating Documents (1 week)

- Research techniques
- Search operators

Chapter I-4: Processing Information (2 weeks)

- Work organization
- Initial research questions
- Synthesis of selected documents
- Connections between different parts
- Final plan of the literature research

Chapter I-5: Bibliography Presentation (1 week)

- Bibliography formatting systems (Harvard, Vancouver, Mixed system, etc.)
- Document presentation
- Citing sources

Part II – Thesis/Report Design:

Chapter II-1: Thesis Structure and Stages (2 weeks)

- Define and delimit the topic (Abstract)
- Research problem and objectives
- Other useful sections (Acknowledgements, Abbreviations table, etc.)
- Introduction (written last)
- Review of specialized literature
- Formulation of hypotheses
- Methodology
- Results
- Discussion
- Recommendations

- Conclusion and future perspectives
- Table of contents
- Bibliography
- Appendices

Chapter II-2: Writing Techniques and Standards (2 weeks)

- Formatting: chapter, figure, and table numbering
- Title page
- Typography and punctuation
- Writing: scientific language, style, grammar, syntax
- Spelling and overall language proficiency for comprehension and expression
- Save, secure, and archive data

Chapter II-3: Workshop – Critical Study of a Manuscript (1 week)

Chapter II-4: Oral Presentations and Defense (1 week)

- How to present a poster
- How to deliver an oral presentation
- Thesis defense

Chapter II-5: How to Avoid Plagiarism (1 week)

- Citation
- Paraphrasing
- Provide complete bibliographic references (including formulas, sentences, illustrations, graphs, data, statistics, etc.)

Evaluation Method:

Final exam: **100%**

References:

(To be provided by the instructor)

1. *M. Griselin et al., Guide de la communication écrite, 2e édition, 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, notices d'utilisation, aides en ligne, Dunod, 2002.*
4. *M. Greuter, Bien rédiger son mémoire ou son rapport de stage, L'Etudiant, 2007.*
5. *M. Boeglin, lire et rédiger à la fac. Du chaos des idées au texte structuré. 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**.*

Suggestions for some discovery subjects

Semester: ..
Discovery TU Code : TUD ..
Subject: Electrical power quality
VHS: 22h30 (Course: 1h30)
Credits: 1
Coefficient: 1

Teaching Objectives:

- Study the main phenomena that degrade power quality (PQ), their origins, and the consequences on equipment through voltage and/or current distortions and network disturbances.
- Understand the impact of nonlinear loads on power quality deterioration and learn about the main solutions to improve it by eliminating disturbances or mitigating them when unavoidable.

Recommended Prior Knowledge:
Electric networks, harmonics, filters, basic electrotechnics, power electronics.

Course Content:

Chapter 1: Introduction to Power Quality (PQ) (3 weeks)

- Context, definition, and terminology of power quality.
- Objectives of PQ measurement.

Chapter 2: Power Quality Degradation (5 weeks)
Common PQ issues and their effects on loads and processes:

- **Voltage sags and interruptions:** Origins of sags and surges, consequences on equipment, flicker concepts.
- **Harmonics and interharmonics:** Origins of harmonics, nonlinear loads, impact on the network and devices.
- **Voltage variations and fluctuations:** Internal/external origins, consequences on production and equipment.
- **Transient phenomena:** EMC concepts, lightning impacts, equipotential bonding, protective conductor PE.
- **Unbalances.**

Chapter 3: Power Quality Levels – Standards (3 weeks)

- Voltage characteristics, terminology, strategy for voltage parameter measurement, standards, network analyzers.

Chapter 4: Solutions to Improve Power Quality (4 weeks)

- **Voltage sags and interruptions:** Reduce frequency, duration, and depth of sags; improve load immunity; use uninterruptible power supplies (UPS).
- **Harmonic currents:** Installation modifications, passive filtering, active filtering, hybrid filtering.
- **Overvoltage protection:** Temporary overvoltage, switching surges (shock coils, automatic compensators), atmospheric overvoltage (lightning).
- **Voltage fluctuations:** Change lighting methods, modify motor starting modes, network modifications.

- **Unbalances:** Balance single-phase loads across three phases, increase transformer capacity and cable sections upstream of imbalance generators, protect machines, use LC loads (Steinmetz connection).

Evaluation Method:
Final Exam: **100%**

References:

1. Guide to Quality of Electrical Supply for Industrial Installations Part 2 : Voltage Dips and Short Interruptions Working Group UIE Power Quality 1996.
2. G.J. Wakileh, Power system harmonics-Fundamental Analysis and Filter Design, Springer-Verlag, 2001.
3. A. Kusko, M-T. Thompson, Power Quality in Electrical Systems, Mc Graw Hill, 2007.
4. F. Ewald Fuchs, M.A.S. Masoum, Power Quality in Power Systems and Electrical Machines, Elsevier Academic Press, 2008.
5. R.C. Dugan, Mark F. Granaghan, Electrical Power System Quality, McGraw Hill, 2001.
6. Cahiers techniques Scheider N° CT199, CT152, CT159, CT160 et CT1.
7. A. Robert, Supply Quality Issues at the Interphase between Power System and Industrial Consumers, PQA 1998.
8. Qualité de l'énergie, Cours de Delphine RIU, INP Grenoble.

Semester: ..
Discovery TU Code : TUD ..
Subject: Industrial Computing
VHS: 22h30 (Course: 1h30)
Credits: 1
Coefficient: 1

Recommended Prior Knowledge:
Combinational and sequential logic, microprocessors and microcontrollers, computer science fundamentals.

Course Content:

Chapter 1: Introduction to Industrial Computing **(2 weeks)**
Chapter 2: Connecting hardware to a microprocessor **(2 weeks)**
Chapter 3: Peripherals and interfaces (Ports, Timers, etc.) **(4 weeks)**
Chapter 4: Serial communication buses (RS-232, DHCP, MODBUS, I2C) **(5 weeks)**
Chapter 5: Data acquisition: ADC and DAC peripherals **(2 weeks)**

Evalutaion Method:
Final Exam: **100%**

References:

1. Baudoin, Geneviève &Virolleau, Férial, « Les DSP famille, TMS 320C54X [texte imprimé] : développement d'applications », Paris : Francis Lefebvre, 2000, ISBN : 2100046462.
2. Pinard, Michel, « Les DSP, famille ADSP218x [texte imprimé] : principes et applications », Paris : Francis Lefebvre, 2000, ISBN : 2100043439 ;
3. Tavernier, Ch., « Les microcontrôleurs PIC : applications », Paris : Francis Lefebvre, 2000, ISBN : 2100059572 ;
4. Tavernier, Ch., « Les microcontrôleurs PIC : description et mise en œuvre », Paris : Francis Lefebvre, 2004, ISBN : 2100067222 ;
5. Cazaubon ,christian, « Les microcontrôleurs HC11 et leur programmation », Paris : Masson, [s.d], ISBN : 2225855277 ;
6. Tavernier, Christian, « Les microcontrôleurs AVR : description et mise en œuvre », Paris : Francis Lefebvre, 2001, ISBN : 2100055798 ;
7. Dumas, Patrick, « Informatique industrielle : 28 problèmes pratiques avec rappel de cours », Paris : Francis Lefebvre, **2004**.

Semester ..:
Discovery TU Code : TUD ...
Subject: Industrial Ecology and Sustainable Development
VHS:22h30(Course: 1h30)
Credits: 1
Coefficient: 1

Course Objectives:

Raise awareness about sustainable development, industrial ecology, and recycling.

Recommended Prior Knowledge:

None

Course Content:

- **Chapter 1:** Origin and evolution of the industrial ecology concept **(02 weeks)**
- **Chapter 2:** Definition and principles of industrial ecology **(02 weeks)**
- **Chapter 3:** Industrial ecology experiences in Algeria and worldwide **(02 weeks)**
- **Chapter 4:** Industrial symbiosis (eco-industrial parks/networks) **(03 weeks)**
- **Chapter 5:** Gaseous, liquid, and solid waste management **(03 weeks)**
- **Chapter 6:** Recycling **(03 weeks)**

Evaluation Method:

Exam: **100%**

References:

1 *Écologie industrielle et territoriale, COLEIT 2012, de Junqua Guillaume , Brullot Sabrina*

1 *Vers une écologie industrielle,comment mettre en pratique le développement durable dans une société hyper-industrielle, SurenErkman 2004*

2 *L'énergie et sa maîtrise. Montpellier Cedex 2 : CRDP de Languedoc-Roussillon, 2004. . ISBN 2-86626-190-9,*

3 *Appropriations du développement durable: émergences, diffusions, traductions B Villalba - **2009***

Semester ..:
Discovery TU Code : TUD …
Subject: Rewables Energies
VHS: 22h30 (Course: 1h30)
Credits: 1
Coefficient: 1

Course Objectives:

Provide students with the scientific foundation to integrate into the research community in the fields of renewable energy, batteries, and sensors associated with engineering applications.

Recommended Prior Knowledge:

Energy conversion devices and technologies

Course Content:

- **Chapter 1:** Introduction to renewable energies (Renewable energy sources: deposits and materials) **(04 weeks)**
- **Chapter 2:** Solar energy (photovoltaic and thermal) **(04 weeks)**
- **Chapter 3:** Wind energy **(03 weeks)**
- **Chapter 4:** Other renewable sources: hydraulic, geothermal, biomass, etc. **(02 weeks)**
- **Chapter 5:** Energy storage, fuel cells, and hydrogen **(02 weeks)**

Evaluation Method:

Exam: **100%**

References:

1. *Sabonnadière Jean Claude. Nouvelles technologies de l'énergie 1: Les énergies renouvelables, Ed. Hermès.*
2. *Gide Paul. Le grand livre de l'éolien, Ed. Moniteur.*
3. *A. Labouret. Énergie Solaire photo voltaïque, Ed. Dunod.*
4. *Viollet Pierre Louis. Histoire de l'énergie hydraulique, Ed. Press ENP Chaussée.*
5. *Peser Felix A. Installations solaires thermiques: conception et mise en œuvre, Ed. Moniteur.*

Semester: ..
Discovery TU Code :TUD ..
Subject: Materials in electrical engineering
VHS: 22h30 (Course: 1h30)
Credits: 1
Coefficient: 1

Course Objectives:

The aim of this course is to provide the basic knowledge necessary to understand the physical phenomena occurring in materials and to make appropriate choices for the design of electrical components and systems. Fundamental characteristics of different types of materials, as well as their behavior in the presence of electric and magnetic fields, are covered.

Recommended Prior Knowledge:

Fundamental physics and applied mathematics

Course Content:

- **Chapter 1:** Understand the operation, composition, technology, and specifications of electrical materials used in power networks. **(03 weeks)**
- **Chapter 2:** Magnetic materials: properties, losses, types, thermal and mechanical properties, characterization, magnets**. (04 weeks**)
- **Chapter 3:** Conductive materials: properties, losses, insulation, testing, and applications. **(04 weeks)**
- **Chapter 4:** Dielectric materials: properties, losses, breakdown and performance, stress, testing. **(04 weeks)**

Evaluation Method:

Exam: **100%**

References:

1. A.C. Rose-Innes and E.H. Rhoderick, Introduction to Superconductivity, Pergamon Press.
2. P. Tixador, Les supraconducteurs, Editions Hermès, Collection matériaux, 1995.
3. P. Brissonneau, Magnétisme et Matériaux Magnétiques Editions Hermès.
4. P. Robert, Matériaux de l' Electrotechnique, Volume II, Traité d'Electricité, d'Electronique et d'Electrotechnique de l'Ecole Polytechnique Fédérale de Lausanne, Edition Dunod.
5. Techniques de l'Ingénieur.
6. R. Coelho et B. Aladenize, Les diélectriques, Traité des nouvelles Technologies, série Matériaux, Editions Hermès, 1993.
7. M. Aguet et M. Ianoz, Haute Tension, Volume XXII, Traité d'Electricité, d'Electronique et d'Electrotechnique de l'Ecole Polytechnique Fédérale de Lausanne, Edition Dunod.
8. C. Gary et al, Les propriétés diélectriques de l'air et les très hautes tensions, Collection de la Direction des Etudes et Recherches d'Electricité de France, Edition Eyrolles, 1984.
9. Matériaux Diélectriques pour le Génie Electrique, Tome 1 & 2, HERMES LAVOISIER, **2007**.

Semester: ..
Discovery TU Code : TUD ..
Subject: Maintenance and operational safety
VHS:22h30(Course: 1h30)
Credits: 1
Coefficient: 1

Course Objectives:

Recommended Prior Knowledge:

Course Content:

- **Chapter 1:** History, context, and definitions of Reliability Engineering (RE). **(02 weeks)**
- **Chapter 2:** Analysis of systems with independent components.
  - Modeling of malfunction logic using fault trees, qualitative and quantitative Boolean analysis, method limitations. **(02 weeks)**
- **Chapter 3:** Analysis of systems considering certain dependencies.
  - System modeling using Markov state graphs, quantitative exploitation of the model, method limitations. **(03 weeks)**
- **Chapter 4:** Analysis of systems considering generalized dependencies.
  - Modeling with Petri nets, quantitative exploitation of the model: stochastic Petri nets. **(03 weeks)**
- **Chapter 5:** Application of reliability engineering methodologies.
  - Reliability, maintainability, availability, and safety. **(03 weeks)**
- **Chapter 6:** Reliability prediction methodology.
  - Forecasting reliability calculations, failure mode analysis, fault diagnosis and maintenance techniques. **(02 weeks)**

Evaluation Method:

Exam: **100%**

References:

1. Patrick Lyonnet, "Ingénierie de la fiabilité, Edition TEC & DOC, Lavoisier, 2006.
2. Roger Serra, "Fiabilité et maintenance industrielle", Cours, Ecole de technologie supérieure ETS, Université de Québec, 2013.
3. David Smith, Fiabilité, maintenance et risque, DUNOD, Paris **2006**

Semester: ..
Discovery TU Code : TUD…
Subject: Implementation of a real-time numerical control
VHS: 22h30 (Course: 1h30)
Credits: 1
Coefficient: 1

Course Objectives:
This course covers the digital control of converter–machine systems using programmable components (µControllers, DSP, ARM, FPGA).

Recommended Prior Knowledge:
Microprocessors and microcontrollers, computer science, control systems, electric machines, power converters.

Course Content:

- **Chapter 1:** Description of real-time systems. **(03 weeks)**
- **Chapter 2:** Digital control of systems. **(04 weeks)**
- **Chapter 3:** Study of PWM implementation techniques on a digital processor. **(04 weeks)**
- **Chapter 4:** Examples of machine control implementation:
  - DC Machine, Asynchronous Machine, Synchronous Machine. **(04 weeks)**

Evaluation Method:
Exam: **100%**

References:

1. B. Bouchez « Applications audionumériques des DSP : Théorie et pratique du traitement numérique », Elektor, 2003.
2. Baudoin, Geneviève &Virolleau, Férial, « Les DSP famille, TMS 320C54X [texte imprimé] : développement d'applications », Paris : Francis Lefebvre, 2000, ISBN : 2100046462.
3. Pinard, Michel, « Les DSP, famille ADSP218x [texte imprimé] : principes et applications », Paris : Francis Lefebvre, 2000, ISBN : 2100043439 ;
4. Tavernier, Ch., « Les microcontrôleurs PIC : applications », Paris : Francis Lefebvre, **2000**.

Semester: ..
Discovery TU Code : TUD…
Subject: Special machines
VHS: 22h30 (Course: 1h30)
Credits: 1
Coefficient: 1

Objectifs de l'enseignement:

A l'issue de cette formation l'étudiant va accroître sa formation par l'acquisition de compétences nouvelles en raison de l'évolution du domaine dans lequel possède déjà une formation, enrichir sa culture et ses connaissances sur les différents types des machines électriques.

Connaissances préalables recommandées :

Machines électriques, construction des machines électriques, conversion électromagnétique.

Contenu de la matière :

Chapitre 1 : Introduction aux machines spéciales (01 semaines)
Chapitre 2 : Machines asynchrones(04 semaines)

- ✓ Moteur monophasé
- ✓ Moteur linéaire

Chapitre 3 : Machines Synchrones(05 semaines)

- ✓ Synchromachines
- ✓ Machine à réluctance variable
- ✓ Moteurs à aimants permanents
- ✓ Moteurs pas à pas
- ✓ Machines supraconductrices

Chapitre 4 : Micromachines(05 semaines)

- ✓ Synchromachines (Selsynes)
- ✓ Moteurs synchrones à hystérésis
- ✓ Génératrices tachymétriques à C.C.
- ✓ Resolvers

Mode d'évaluation :

Examen : 100%.

Références bibliographiques:

1. M. Kostenko et L. Piotrovski, Machines électriques
2. Réal-Paul BOUCHARD et Guy OLIVIER, Conception de moteurs asynchrones
3. B.Saint –Jean, Electrotechnique et machines électriques

Semester: ..
Master : Electrical control
Dicsovery TU Code : TUD
Subject: Transient Regime of Electrical Systems
VHS: 22h30 (Course: 1h30)
Credits: 1
Coefficient: 1

Course Objectives:
To properly size the protection devices of electrical systems, the study of transient regimes is essential. This course therefore focuses on the transient behavior of electrical machines. The dynamic performance of electrical machines is addressed both in the linear regime and in the nonlinear regime, where the concept of extending linear models to saturated conditions is introduced.

Recommended Prerequisites:
Electrical circuits, electrical machines, machine modeling, power electronics.

Course Content:

I. Dynamic Model of the Induction Machine (6 weeks)

- Review of relative and symmetrical components
- Analysis of transient regimes of induction machines
- Operation as a motor
- Operation as a generator
- Dynamic performance during a three-phase fault in the induction machine

II. Dynamic Model of the Synchronous Machine (5 weeks)

- Analysis of transient regimes of synchronous machines
- Operation as an alternator
- Operation as a motor
- Dynamic performance during a three-phase fault in the synchronous machine

III. Dynamic Model of the DC Machine (4 weeks)

- Analysis of transient regimes of the machine
- Operation as a generator
- Operation as a motor

Evaluation Method:

Examen : 100%.

Semester : ..
Master : Electrical control
Discovery TU Code : TUD
Subject: Industrial automation
VHS: 22h30 (Course: 1h30)
Credits: 1
Coefficient: 1

Course Objectives:

- Understand industrial automated systems from a control-command perspective.
- Learn the methodology for studying automated systems.
- Develop specifications and requirements documents.
- Program and configure programmable logic controllers (PLCs).
- Be able to implement industrial systems designed around industrial PLCs.

Recommended Prerequisites:
Combinational and sequential logic, electrical schematics and equipment, industrial technologies.

Course Content:

Chapter I: Industrial Programmable Controllers (4 weeks)

- Basic concepts
- Overall function of an automated system
- Production systems and automation
- Structure of a production automation system (PAS)
- Hardware architecture of PLCs
- Criteria for selecting a PLC
- Synthesis of sequential systems
- Methods for analyzing the operation of automated systems

Chapter II: Grafcet Tool (6 weeks)

- Fundamental concepts
- Basic principles and evolution rules
- Basic structures
- Concept of sequences
- Special structures
- Advanced concepts
- Hierarchical structure of a Grafcet
- Forcing and freezing of situations
- Conversion of a Grafcet into equations

Chapter III: PLC Languages and Programming (5 weeks)

- Common objects
- Different types of programming languages:

- SFC (Sequential Function Chart)
- LD (Ladder Diagram)
- IL (Instruction List)
- FBD (Function Block Diagram)
- ST (Structured Text)

- Ladder (LD) language and symbols
- Implementation of automation systems using PLCs

Evaluation Method:
Exam: **100%**

Semester : ..
Master : Electrical control
Discovery TU Code : TUD
Subject: Automation and Industrial Computing
VHS: 22h30 (Course: 1h30)
Credits: 1
Coefficient: 1

Course Objectives:
Understand the operation and architecture of automated systems and the contribution of industrial computing to these systems.

Recommended Prerequisites:
Algorithmics, programming, electrical circuits and systems.

Course Content:

Part 1

1. Structure of an automated system: relational part, control part, and operative part
2. Examples of automated systems: heating box, lighting box, home automation model, etc.
3. Modbus communication protocol: Ethernet transfer, Modbus frames, example of master-slave exchange
4. Programming languages for automation applications:
   4.1. Textual languages: IL (Instruction List, e.g., ASSEMBLER); ST (Structured Text, e.g., Matlab)
   4.2. Graphical languages: FBD (Function Block Diagram, e.g., Crouzet Millenium 3); LD (Ladder Diagram, programming Boolean equations true/false); SFC (Sequential Function Chart, e.g., GRAFCET, and all sequential processes)

Part 2

1. Introduction to industrial computing and microprogrammed systems
2. Architecture of microcontrollers
3. Overview of microcontroller components and selection criteria
4. Review of binary numbers and coding systems
5. Instructions
6. Review of combinational and sequential logic
7. Study of microcontroller operation: PIC 18F4520
8. Programming in Assembly – review of flowcharts
9. Introduction to interrupts
10. Study of an Assembly program with interrupt handling
11. Overview of integrated microcontroller functions (timer, PWM, etc.)
12. Introduction to the C language for microcontrollers / specifics for PIC 18F4520

Evaluation Method:
Exam: 100%

References:

1. Michel Lauzier, Gérard Colombari « Automatique et informatique industrielle. Tome 1, Outils de description», 96p, Foucher, 1994.
2. Michel Lauzier, Gérard Colombari « Automatique et informatique industrielle. Tome 2, Conception des systèmes », 128p, Foucher, 1995.
3 Jean Perrin , Francis Binet, J. J. Dumery , Christian Merlaud, J. P. Trichard « Automatique et informatique industrielle bases theoriquesmethodologiques et techniques » , 336p, NATHAN (12 novembre 2004).
4. Jean-Louis Fanchon, J.M. Bleux « Automatismes industriels », 128p, NATHAN 2001
D Blin, J Danic, R Le Garrec, F Trolez, Jc Seite « Automatismes et informatique industrielle », Educalivre 1 Août **1999**.

Semester : ..
Master : Electrical control
Discovery TU Code : TUD
Subject: Control of future energy systems
VHS: 22h30 (Course: 1h30)
Credits: 1
Coefficient: 1

Course Syllabus:

1. **Review of New and Renewable Energy Systems:** General concepts, non-renewable electrical energy, renewable electrical energy, microgrids, monitoring and control of electrical energy systems, the need for intelligent electrical systems: Smart House, Smart City, Smart Grid, smart electricity meters, communication technologies for smart grids (ZigBee, WiMAX, and other communication types).
2. **Artificial Intelligence in Future Energy Systems:**
   - AI for domestic networks (Smart Home)
   - AI for microgrid balance (Smart City)
   - AI for overall supply-demand balance (Smart Grids)
   - AI for marketplaces and collaborative platforms
   - AI for predictive maintenance and operations
   - AI for digital workforces
3. **How AI Redefines Energy Challenges:** Impacts on providers (producers), customers (consumers), and intermediaries or facilitators. Fundamental transformations in the energy ecosystem.
4. **Artificial Intelligence as a Robust Optimization Tool:** Optimizing energy production and consumption.
5. **Introduction to Big Data and IoT Platforms:** Real-time aggregation of heterogeneous data.

Evaluation Method:
Exam: **100%**

References:

1. C. SABONNADIÈRE et N. HADJSAID – *Smart-grids : les réseaux électriques intelligents*, HERMES, 2012.

2. N. HADJSAID – *Les réseaux électriques de distribution : de la production décentralisée aux smart-grids*, HERMES, 2010.

3. BOUCKAERT Stéphanie « Contribution des Smart Grids à la transition énergétique : évaluation dans des scénarios long terme ». Thèse PhD, Ecole Nationale Supérieure des Mines de Paris. 2013. https://pastel. archives-ouvertes.fr/pastel-00959266/document
4. L. Freris et D. Infield, " Les énergie renouvelable pour la production d'électricité ", DUNOD, Paris 2009.
5. BURTON T. SHARPE D. JENKINS N. BOSSANYI E. HASSAN G. «Wind energy Handbook», England, 2001.
6. Riolet E., *L'Énergie solaire et photovoltaïque pour le particulier*, Eyrolles, 2010.
7. Bryans L., Flynn D., Fox B. *et al*, *Énergie électrique éolienne*, Dunod, 2015.
8. Damien A., *La Biomasse énergie*, Dunod, 2013.
9. Ginocchio R., Viollet P.-L., *L'Énergie hydraulique*, Lavoisier, 2012.
10.« La chaîne de valeur du marché des smart grids », www.items.fr. 2012.
11. Smart Grids-cre, Dossier « les compteurs évolués », http://www.smartgridscre.fr/index.php.
12. Page d'accueil de ZigBee. surhttp://www.zigbee.org
13. SmartGrids – CRE, "Smart Grid City : une gestion locale des sources d'approvisionnement et de consommation", 2011, disponible sur : http://www.smartgrids-cre.fr/index.php?p=smartcities-smart-grid-city

14.Chambolle.T, Meaux.F, ‘ Rapport sur les nouvelles technologies de l’énergie ‘, Paris 2004.
15. Frédéric Scibetta, Yvon Moysan , EricDosquet, Frédéric Dosquet « L'Internet des objets et la data : L'intelligence artificielle comme rupture stratégique », DUNOD, **2018**.

Semester: ..
Discovery TU Code : TUD ..
Subject : Electrical machines in dynamic mode
VHS: 22H30 (Course: 1h30)
Credits: 1
Coefficient: 1

Course Objectives:
Enable students to acquire knowledge on the modeling of synchronous and asynchronous machines under dynamic conditions.

Recommended Prerequisites:
Mathematics, operation of electrical machines under steady-state conditions.

Course Content:

Chapter 1: Dynamic Modeling of the Synchronous Machine

- Structure of the synchronous machine and phenomena involved in its operation – simplifying assumptions
- Stator and rotor voltage equations in the real axis (salient-pole machine)
- Flux equations – Calculation of inductances – case of smooth-pole machine – Mechanical equation and calculation of electromagnetic torque – issues related to system resolution
- Axis transformations – Clarke (Concordia) and Park
- Machine model in the Park reference frame – expression of electromagnetic torque – advantages of the Park model – state-space model
- Limitations of the obtained model

Chapter 2: Dynamic Modeling of the Asynchronous Machine

- Structure of the asynchronous machine and phenomena involved in its operation – simplifying assumptions
- Stator and rotor voltage equations in the real axis (wound-rotor machine)
- Flux equations – Calculation of inductances – case of squirrel-cage rotor – Mechanical equation and expression of electromagnetic torque
- Machine model in the Park reference frame – different positions of the reference frame – expression of electromagnetic torque – state-space model
- Limitations of the obtained model

Evaluation Method:
Exam: **100%**

References:

1. Modélisation et commande de la machine asynchrone, J.P. Caron et J.P. Hautier, Technip, 1995
2. Control of Electrical Drives, W. Leonard, Springer-Verlag, 1996
3. Vector control of AC machines, Peter Vas, Oxford University Press, 1990
4. Méthodes de commande des machines électrique, R. Husson, Hermès.
5. Power Electronics and AC Drives, Prentice-Hall, B.K. Bose, 1986
6. Modern Power Electronics and AC Drives, B-K. Bose, Prentice-Hall International Edition, 2001.

7. Actionneurs électriques, Guy Grellet et Guy Clerc, Eyrolles, 1997
8. Commande des moteurs asynchrone, Modélisation, Contrôle vectoriel et DTC, Volume 1, C. Canudas De 9. Wit, Edition Hermès Sciences, Lavoisier, Paris **2004**.