الجمهورية الجزائرية الديمقراطية الشعبية
People's Democratic Republic of Algeria
وزارة التعليم العالي والبحث العلمي
Ministry of Higher Education and Scientific Research
اللجنة البيداغوجية الوطنية لميدان العلوم و التكنولوجيا
National Teaching Committee for Science and Technology

ACADEMIC MASTER HARMONIZED

National Program

Update 2022

Domain	Channel	Speciality
Sciences and Technologies	***Automatic***	***Automation and Systems***

I - Master's degree profile

Access conditions

(Indicate the bachelor's degree specialities that may give access to the Master's degree)

Channel	Harmonised Masters	Licences giving access to master	Classification according to licence compatibility	Coefficient allocated to the licence
Automatic	Automation and systems	Automatic	**1**	**1.00**
		Electronics	**2**	**0.80**
		Electrical engineering	**2**	**0.80**
		Other licences in the ST field	**3**	**0.60**

II - Semester-by-semester course organisation sheets of the speciality

Semester 1

Teaching unit	Materials – Title	Credits	Coefficient	Number of hours per week – Courses	DW	PW	Semester Hours (15 weeks)	Complementary work Consultation (15 weeks)	Assessment method – Continuous assessment	Examination
Fundamental EU Code: UEF 1.1.1 Credits: 10 Coefficients: 5	Multivariable linear systems	6	3	3h00	1h30		67h30	82h30	40%	60%
	Signal processing	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental EU Code: UEF 1.1.2 Credits: 8 Coefficients: 4	Converter-machine association	4	2	1h30	1h30		45h00	55h00	40%	60%
	Optimization	4	2	1h30	1h30		45h00	55h00	40%	60%
EU Methodology Code: UEM 1.1 Credits: 9 Coefficients: 5	Identification techniques	3	2	1h30		1h00	37h30	37h30	40%	60%
	PW Multivariable linear systems	2	1			1h30	22h30	27h30	100%	
	PW Signal processing/ PW Optimisation	2	1			1h30	22h30	27h30	100%	
	PW Converter-machine association	2	1			1h30	22h30	27h30	100%	
EU Discovery Code: UED 1.1 Credits: 2 Coefficients: 2	Choice of material	1	1	1h30			22h30	02h30		100%
	Choice of material	1	1	1h30			22h30	02h30		100%
Cross-cutting EU Code: UET 1.1 Credits: 1 Coefficients: 1	Technical english and terminology	1	1	1h30			22h30	02h30		100%
Total semester 1		**30**	**17**	**13h30**	**6h00**	**5h30**	**375h00**	**375h00**		

Semester 2

Teaching unit	Materials / Title	Credits	Coefficient	Number of hours per week: Courses	DW	PW	Semester Hours (15 weeks)	Complementary work Consultation (15 weeks)	Assessment method: Continuous assessment	Examination
Fundamental EU Code: UEF 1.2.1 Credits: 10 Coefficients: 5	Nonlinear systems	6	3	3h00	1h30		67h30	82h30	40%	60%
	Optimal control	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental EU Code: UEF 1.2.2 Credits: 8 Coefficients: 4	Applied Electronics	4	2	1h30	1h30		45h00	55h00	40%	60%
	PLC and supervision	4	2	1h30	1h30		45h00	55h00	40%	60%
EU Methodology Code: UEM 1.2 Credits: 9 Coefficients: 5	Concepts and language of graphic programming	3	2	1h30		1h00	37h30	37h30	40%	60%
	PW Nonlinear systems/ PW Optimal control	2	1			1h30	22h30	27h30	100%	
	PW Applied Electronics	2	1			1h30	22h30	27h30	100%	
	PW PLC and supervision	2	1			1h30	22h30	27h30	100%	
EU Discovery Code: UED 1.2 Credits: 2 Coefficients: 2	Choice of material	1	1	1h30			22h30	02h30		100%
	Choice of material	1	1	1h30			22h30	02h30		100%
Cross-cutting EU Code: UET 1.2 Credits: 1 Coefficients: 1	Compliance with ethical and integrity standards and rules	1	1	1h30			22h30	02h30		100%
Total semester 2		**30**	**17**	**13h30**	**6h00**	**5h30**	**375h00**	**375h00**		

Semester 3

Teaching unit	Materials: Title	Credits	Coefficient	Number of hours per week: Courses	DW	PW	Semester Hours (15 weeks)	Complementary work Consultation (15 weeks)	Assessment method: Continuous assessment	Examination
Fundamental EU Code: UEF 2.1.1 Credits: 10 Coefficients: 5	Predictive and adaptive control	6	3	3h00	1h30		67h30	82h30	40%	60%
	Intelligent control	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental EU Code: UEF 2.1.2 Credits: 8 Coefficients: 4	System diagnosis	4	2	1h30	1h30		45h00	55h00	40%	60%
	Control of handling robots	4	2	1h30	1h30		45h00	55h00	40%	60%
EU Methodology Code: UEM 2.1 Credits: 9 Coefficients: 5	Real-time systems	3	2	1h30		1h00	37h30	37h30	40%	60%
	PW Predictive and adaptive control /PW Intelligent control	2	1			1h30	22h30	27h30	100%	
	PW System diagnosis	2	1			1h30	22h30	27h30	100%	
	PW Control of handling robots	2	1			1h30	22h30	27h30	100%	
EU Discovery Code: UED 2.1 Credits: 2 Coefficients: 2	Choice of material	1	1	1h30			22h30	02h30		100%
	Choice of material	1	1	1h30			22h30	02h30		100%
Cross-cutting EU Code: UET 2.1 Credits: 1 Coefficients: 1	Documentary research and brief design	1	1	1h30			22h30	02h30		100%
Total semester 3		**30**	**17**	**13h30**	**6h00**	**5h30**	**375h00**	**375h00**		

Discovery UE *(S1, S2 and S3)*

1- Virtual instrumentation
2- Image processing and vision
3- Intelligent sensors
4- Artificial intelligence
5- Intelligent vision
6- Robotics (mobile robotics, humanoid robotics, service robotics, environmental robotics, etc.)
7- Computer-aided design CAD
8- Electric vehicles
9- Hydraulics and pneumatics
10- Web programming
11- Operational reliability
12- Maintenance management
13- Telecommunications Applications
14- Biotechnology
15- Biomedical Technologies

Semester 4

Work placement in a company or research laboratory, culminating in a dissertation and oral presentation.

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

This table is given for information only

Evaluation of the Master's final project

- Scientific merit (Jury's assessment) /6
- Writing the dissertation (Assessment by the jury) /4
- Presentation and answers to questions (Jury's assessment) /4
- Framer's assessment /3
- Presentation of the placement report (Assessment by the jury) /3

III - Detailed timetable by subject for semester S1

Semester: 1
Teaching unit: UEF 1.1.1
Subject: Multivariable linear systems
VHS: 67h30 (Classes: 3h00, Workshops: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives

The objective of the course is to provide a methodology for the design of different control laws for linear invariant multivariable systems, in the context of the state approach.

Previous knowledge recommended:

Students must have the following knowledge

- Linear servo systems
- Sampled systems ;

Subject content:

Chapter 1: Introduction (2 weeks)
Objectives of this course, Reminder of matrix calculation, Reminder of state approach concepts, Difference between SISO and MIMO.

Chapter 2: State representation of multivariable systems (MS). (2 weeks)
Definitions, Different system representations, Solving the equation of state, Application examples

Chapter 3: Commandability and Observability. (2 weeks)
Introduction, Kalman controllability criterion, Output controllability, Observability criterion, Duality between controllability and observability, Study of some canonical forms.

Chapter 4: Representation of SMs by transfer matrix. (3 weeks)
Introduction, From state representation to transfer matrix representation, Gilbert's method, Invariant method: Smith-McMillan form, Method by reduction of a realisation

Chapter 5: SM feedback control (4 weeks)
Formulation of the state feedback pole placement problem, Computational methods for multivariable systems, State observer and output feedback control (i.e. with state observer) of SMs. Non-interactive SM control, Implementation.

Assessment method

Continuous assessment: 40%; examination: 60%.

References:

1- De Larminat, Automatique, Hermès, 1995.

2- B. Pradin, G. Garcia ; "automatique linéaire : systèmes multivariables", course handouts, INSA de Toulouse, 2011.
3- Caroline Bérard, Jean-Marc Biannic, David Saussié, ''La commande multivariable'', Editions Dunod, 2012.
4- G. F. Franklin, J. D. Powell and A. E. Naaeimi, Feedback Control Dynamics Systems (Addison-Wesly, 1991).
5- K. J. Astrôm, B. Wittenmark, Computer-Controlled Systems, Theory and design. Prentice Hall, New Jersey, 1990.
6- W. M. Wonman, Linear Multivariable Control: A Geometric approach. Springer Verlag, New York, 1985.
7- Hervé Guillard, Henri Bourlès, "Control Systems. Performance & Robustness. Régulateurs Monovariables Multivariables Applications Cours & Exercices Corrigés", Editions Technosup, 2012.
8- Caroline Bérard , Jean-Marc Biannic , David Saussié, Commande multivariable, Dunod, Paris, 2012.

Semester: 1
Teaching unit: UEF 1.1.1
Subject 1: Signal processing
VHS: 45h00 (Lectures: 1h30, TD: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Master the tools of time and frequency representation of analogue and digital signals and systems and carry out basic processing such as filtering and digital spectral analysis.

Previous knowledge recommended:

Students must have the following knowledge

- Signal theory
- The foundations of mathematics

Subject content:

Chapter 1: Review of the main results of signal theory (2 weeks

Signals, Fourier series, Fourier transform and Parseval's theorem, convolution and correlation.

Chapter 2. Analysis and synthesis of filters (4 weeks)

Time and frequency analysis of analogue filters, passive and active filters, first- and second-order low-pass filters, first- and second-order high-pass filters, bandpass filters, other filters (Chebyshev, Butterworth).

Chapter 3: Signal Sampling (1 Week)

From continuous signal to digital signal Sampling, reconstruction and quantification.

Chapter 4: Discrete transforms and windowing: From the Discrete Time Fourier Transform (DTFT) to the Discrete Fourier Transform (DFT), the Fast Fourier Transform (FFT (3 weeks)

Chapter 5: Analysis and synthesis of digital filters **(5 weeks)**

Filter template definition

RIF and RII filters

Lattice filters

RIF filter synthesis: window method

Synthesis of RII digital filters: Bilinear method

Assessment method:

Continuous assessment: 40%; Examination: 60%.

References

1- Francis Cottet, Signal processing and data acquisition - Courses and corrected exercises, 4th edition, Dunod, Paris, 2015.
2- Tahar Neffati, Traitement du signal analogique : Cours, Ellipses Marketing, 1999.
3- Messaoud Benidir, Théorie et traitement du signal : Méthodes de base pour l'analyse et le traitement du signal, Dunod, 2004.

4- Maurice Bellanger, Traitement numérique du signal : Théorie et pratique, 9(ième) édition, Dunod, Paris, 2012.
5- Étienne Tisserand Jean-François Pautex Patrick Schweitzer, Analyse et traitement des signaux méthodes et applications au son et à l'image 2ième édition, Dunod, Paris, 2008.
6- Patrick Duvaut, François Michaut, Michel Chuc, Introduction au traitement du signal - exercices, corrigés et rappels de cours, Hermes Science Publications, 1996.

Semester: 1
Teaching unit: UEF 1.1.2
Subject: Association of converters and machines
VHS: 45h00 (Lectures: 1h30, TD: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives

To study the various combinations of converters and rotating electrical machines in order to control the torque and speed of a system.

Previous knowledge recommended:

Students must have the following knowledge

- Power electronics.

Subject content:

Chapter 1: DC-AC converters **(4 weeks)**
- Uninterruptible power supply structures,
- Principle of PWM converters

Chapter 2: Direct current motor : (2 weeks)
- Principle, structure and characteristics
- Speed variation.
.
Chapter 3: Alternating current motor : (2 weeks)
- Principle, structure and characteristics
- Speed variation.

Chapter 4. Converter - machine association: (4 Weeks)
- Torque and speed control,
-Variable speed drives for synchronous machines
-Variable speed drive for asynchronous machines

Chapter 5: Selection criteria and implementation of a variable speed drive. (3 weeks)

Assessment method

Continuous assessment: 40%; examination: 60%.

References:

1. F. LABRIQUE, G. SEGUIER, R. BAUSIERE, Volume 4: La conversion continu-alternatif, Lavoisier TEC & DOC, 2nd edition, 1992.
2. Daniel Gaude, Electrotechnique tome 2 : Electronique de puissance, conversion électromagnétique, régulation et asservissement, Cours complet illustré de 97 exercices résolus, Eyrolles, 2014.
3. Francis Milsant, Electrical Machines (BTS, IUT, CNAM), vol. 3: Machines synchrones et asynchrones, Ellipses Marketing, 1991.

4. B.K. Bose, Power Electronics and AC drives, Prentice-Hall, 1986.
5. EDF/TECHNO-NATHAN/GIMELEC, la vitesse variable, l'électronique maitrise le mouvement, Nathan, 1992. 1991.
6. P. Mayé, Moteurs électriques industriels, Licence, Master, écoles d'ingénieurs, Dunod Collection: Sciences sup 2011.
7. J. Bonal, G. Séguier, Entraînements électriques à vitesse variable. Volume 3, Interactions convertisseur-réseau et convertisseur-moteur-charge, Tec & Doc, 2000.

Semester: 1
Teaching unit: UEF 1.1.2
Subject 1: Optimisation
VHS: 45h00 (Lectures: 1h30, TD: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The aim of the course is to master the complex optimisation techniques encountered in the management of large production systems, machines and materials, in industry, commerce and administration. The aim is to provide decision support for maximum performance.

Previous knowledge recommended:

Students must have the following knowledge

- Mathematics.

Subject content:

Chapter 1: Mathematical review (Positivity, Convexity, Minimum, Gradient and Hessian) (2 weeks)

Chapter 2. Unconstrained optimisation - local methods (3 Weeks)

Unidimensional search methods
Gradient methods
Conjugate direction methods
Newton's method
Levenberg-Marquardt method
Quasi-Newton methods

Chapter 3. Unconstrained optimisation - global methods (3 weeks)

Projected gradient method
Lagrange-Newton for inequality constraints
Projected Newton method (for boundary constraints)
Penalty method
Duality method: Uzawa method

Chapter 4. Linear programming (3 weeks)

Chapter 5. Non-linear programming (4 weeks)

Assessment method:

Continuous assessment: 40%; Examination: 60%.

References: (If possible

1- Stephen Boyd, Lieven Vandenberghe Convex Optimization, Cambridge University Press, 2004.
2- Michel Bierlaire, Optimization: principles and algorithms, EPFL, 2015.
3- Jean-Christophe Culioli, Introduction à l'optimisation, Ellipses, 2012.
4- Rémi Ruppli, Linear Programming: Ideas and Methods, Ellipses, 2005.

5- Pierre Borne, Abdelkader El Kamel, Khaled Mellouli, Linear Programming and Applications: Eléments de cours et exercices résolus, Technip, 2004.

Semester: 1
Teaching unit: UEM 1.1
Subject: Identification techniques
VHS: 37h30 (lectures: 1h30, practical work: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives

This course enables students to master modern automatic techniques for the identification and estimation of system models, both in terms of theoretical principles and practical implementation using numerous examples.

Previous knowledge recommended:

Students must have the following knowledge

- Power electronics.

Subject content:

Chapter 1: **Reminder: Identification based on equation error: least square method** (linear parametrisation). **(2 Weeks)**

Chapter 2: Instrumental variables method **(2 weeks)**

Chapter 3: Prediction error method **(5 weeks)**
Structures without noise model
Structures with noise model
Minimising prediction error
Frequency analysis of prediction error

Chapter 4.Closed loop identification **(1 Week)**
Identification without external excitation
Identification with external excitation

Chapter 5: **Practical aspects of identification** **(3 weeks)**
Signal conditioning
Choice of sampling period
Choice of excitation signal
Order estimation

Chapter 6: **Model validation** **(2 weeks)**
Validation against the desired goal
Validation of the model with experimental data
Validation using statistical methods
Validation using heuristic methods

PW Identification techniques :
PW 1: Least square method

PW 2: Instrumental variables method
PW 3: Prediction error method
PW 4: Prediction error method
PW 5: Closed loop identification
PW 6: Model validation

Assessment method:

Continuous assessment: 40%; Examination: 60%.

References

1- Etienne DOMBRE, Wisama KHALIL, Modélisation, identification et commande des robots, published by HERMÈS / LAVOISIER, 1999.
2- E. Walter, L. Pronzato: Identification de modèles paramétriques, Masson, 1997.
3- Ioan Landau, Systems Identification, Hermes Science Publications, 1998.
4- Bruno Despres, Eulerian and Lagrangian Conservation Laws and Numerical Methods (Mathematics & Applications), Springer, 2010
5- Michel Vergé, Daniel Jaume, Modélisation structurée des systèmes avec les Bond Graphs, TECHNIP, 2003.
6- P. Borne et al. Modélisation et identification des processus. Technip, Paris, 1993.
7- J. Richalet. Pratique de l'identification. Hermes, Paris, 1991.

Semester: 1
Teaching unit: UEM 1.1
Subject: PW Multivariable linear systems
VHS: 22h30 (PW: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives

The objective is to provide a methodology for the design of different control laws for linear invariant multivariable systems, namely: state and output feedback control.

Recommended prior knowledge

Previous knowledge of linear algebra and multivariable linear servo systems.

Subject content:

PW 1: Introduction to Matlab
PW 2: State representation of multivariable systems
PW 3: Commandability and Observability.
PW 4: Representation of SM by transfer matrix.
PW 5: Status feedback control for SMs.
PW 6: Observation of SM status

Assessment method: 100% assessment

Semester: 1
Teaching unit: UEM 1.1
Subject: PW Signal Processing / Optimization
VHS: 22h30 (PW: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives

For PW SP, consolidate the knowledge acquired during the "Signal processing" course with practical work to better understand and assimilate the content of this subject.

For the PW optimization, to enable students to use and master the theoretical concepts studied in the course.

Recommended prior knowledge

Course content

Subject content:

PW Signal processing:

PW 1: Signal representation and Fourier applications in Matlab
PW 2: Analogue filtering
PW 3: Discrete Fourier Transform
PW 4: Digital Filtering RII
PW 5: Digital Filtering RIF

PW Optimization:

PW 1: Introduction to Matlab
PW 2: Unconstrained optimization
PW 3: Unconstrained Optimization
PW 4: Linear programming
PW 5: Non-linear programming

Assessment method: 100% assessment

Semester: 1
Teaching unit: UEM 1.1
Subject: PW Converter-machine association
VHS: 22h30 (PW: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives

This practical work will enable the student to put into practice and consolidate the knowledge acquired in the Converter-Machine Association module.

Recommended prior knowledge

Course content.

Subject content:

PW 1: DC-AC converters
PW 2: Variable Speed Drive for Motor
PW 3: Variable Speed Drive for AC Motor
PW 4: Variable speed drives for synchronous machines
PW 5: Variable speed drive for asynchronous machines

Assessment method: 100% assessment

Semester: 1
Teaching unit: UET 1.1
Subject 1: Technical English and terminology
VHS: 22h30 (Class: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

Introduce students to technical vocabulary. Reinforce their knowledge of the language. Help them understand and summarise a technical document. Enable them to understand a conversation in English in a scientific context.

Previous knowledge recommended:

Basic English vocabulary and grammar

Subject content:

- Reading comprehension: Reading and analysis of texts relating to the subject.

- Listening comprehension: Using authentic popular science videos, take notes, summarise and present the document.

- Oral expression: Presentation of a scientific or technical subject, preparation and exchange of oral messages (ideas and data), telephone communication, body language.

- Written expression: Extracting ideas from a scientific document, writing a scientific message, exchanging information in writing, writing CVs, letters applying for work placements or jobs.

Recommendation: It is strongly recommended that the subject leader presents and explains at the end of each session (at most) ten or so technical words from the speciality in the three languages (if possible) English, French and Arabic.

Assessment method:

Review: 100%.

References :

1. *P.T. Danison, Guide pratique pour rédiger en anglais: usages et règles, conseils pratiques, Editions d'Organisation 2007*
2. *A. Chamberlain, R. Steele, Guide pratique de la communication: anglais, Didier 1992*
3. *R. Ernst, Dictionnaire des techniques et sciences appliquées: français-anglais, Dunod 2002.*
4. *J. Comfort, S. Hick, and A. Savage, Basic Technical English, Oxford University Press, 1980*
5. *E. H. Glendinning and N. Glendinning, Oxford English for Electrical and Mechanical Engineering, Oxford University Press 1995*
6. *T. N. Huckin, and A. L. Olsen, Technical writing and professional communication for nonnative speakers of English, Mc Graw-Hill 1991*
7. *J. Orasanu, Reading Comprehension from Research to Practice, Erlbaum Associates 1986.*

III - Detailed S2 semester syllabus by subject

Semester: 2
Teaching unit: UEF 1.2.1
Subject 1: Nonlinear systems
VHS: 67h30 (Classes: 3h00, Workshops: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:

The aim of this course is: to make students aware of the stability problems of non-linear systems and to provide them with mathematical tools for analysis, to introduce non-linear control methods such as techniques based on differential geometry and the sliding mode approach. The methodologies presented make use of both time and frequency representations.

Previous knowledge recommended:

Students must have the following knowledge

- Signal theory
- The foundations of mathematics

Subject content:

Chapter 1: Introduction : **(1 Week)**
Static non-linearity and Equilibrium Points, examples of non-linear systems.
The simple pendulum. The non-linear electrical oscillator. Limit cycles. Chaotic orbits. The chaotic pendulum. The polar pendulum. The crane

Chapter2: Phase plan : **(3 weeks)**
Second-order systems. Construction of the phase portrait. Elimination of implicit/explicit time. Isocline method. Van der Pol oscillator. Recall linear systems: characterisation of orbits by eigenvalues. Singular point index. The index theorem. The Poincaré-Bendixson theorem. The Bendixson condition.

Chapter 3: First harmonic method : **(3 weeks)**
Assumptions. Decomposition into harmonics. Equivalent of the first harmonic. Common non-linearities. Saturation. Dead zone. Relays. Hysteresis. Linear system and controller. Nyquist criterion. Additional complex gain. Modified Nyquist criterion. Estimation of limit cycle parameters. Frequency independent equivalent. Reliability of first harmonic analysis.

Chapter 4: Foundations of Lyapunov theory: **(2 weeks)**
Stability: intuitive definition. Notion of distance. Stability: formal definition. Asymptotic stability. Direct Lyapunov method. Positive definite function. Lyapunov function. Example: robot. Local stability theorem. Exponential stability. Global stability. Lyapunov function for linear systems. Local stability and linearisation. Disadvantages of the indirect method. LaSalle invariance theorem. Krasovskii method. Variable gradient method. Instability and Chetaev's theorem

Chapter 5: Passivity Theory : **(2 Weeks)**
Intuition. Static system. Storage function. Parallel / serial / feedback connection. Passivity and SISO linear systems. Positive real system. Link between Lyapunov and positive real system. Kalman-Yakubovich-Popov theorem. Absolute stability. Aizerman conjecture. Circle criterion. Popov criterion.

Chapter 6: Notion of differential geometry : **(3Weeks)**
Vector field. Dual space. Covectors. The gradient seen as a field of covectors. Lie derivative. Lie bracket. Differomorphism. Frobenius theorem. Involutive family. Linearisation conditions. Back to the flexible joint robot example

Chapter 7. Control of nonlinear systems **(3Weeks)**
1. General
2. Linearization control
3. Sliding mode control

Assessment method:

Continuous assessment: 40%; Examination: 60%.

References

1. Ph. Müllhaupt, Introduction à l'analyse et à la commande des systèmes non linéaires, PPUR, 2009.
2. Gille, J.C., Decaulne, P., Pelegrin, M., Méthodes d'étude des systèmes asservis non linéaires, Dunod, 1975.
3. Atherton, D.P., 'Nonlinear Control Engineering. Describing Function Analysis and Design', Van Nostrand Reinhold Company, 1975.
4. Utkin, V.I., 'Sliding modes and their application to variable structure systems', MIR Publishers, 1978.
5. Khalil, H.K., 'Nonlinear systems', Prentice Hall, Englewood Cliffs, NJ, 1980.
6. Nijmeijer, H., Van der Shaft. A.J., 'Nonlinear dynamical control systems', Springer Verlag, 1990.
7. Isidori, A., 'Nonlinear control systems', Springer Verlag, 1995.
8. Yves Granjon, Automatique - Systèmes linéaires, non linéaires - 2e édition: Cours et exercices corrigés, Dunod; Edition: 2nd edition, 2010.
9. RASVAN Vladimir, STEFAN Radu, Nonlinear systems: theory and applications, Lavoisier, 2007.
10. J.-C. Chauveau, Systèmes asservis linéaires et non linéaires: Exercices et problèmes résolus, Educalivre, 1995.
11. Philippe Müllhaupt, Introduction à l'analyse et à la commande des systèmes non linéaires, PPUR, 2009.

Semester: 2
Teaching unit: UEF 1.2.1
Material: Optimal control
VHS: 45h00 (Lectures: 1h30, DW: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives

The aim of the course is to present the theoretical and numerical aspects of this discipline, as well as applications in a wide range of fields

Previous knowledge recommended:

Students must have the following knowledge

- Linear servo systems
- Sampled systems ;

Subject content:

Chapter 1: Introduction: Optimal control problem **(1 Week)**
Chapter 2: Minimum-time control **(3 weeks)**
Chapter 3: Linear Quadratic Control **(4 weeks)**
Chapter 4: Linear Quadratic Gaussian Control **(4 weeks)**
Chapter 5: Numerical methods in optimal control **(3 weeks)**
.

Assessment method

Continuous assessment: 40%; examination: 60%.

References:

1. ABOU-KANDIL Hisham, La commande optimale des systèmes dynamiques, Lavoisier, 2004.
2. Michel Dion, Dumitru Popescu, Commande optimale - Conception optimisée des systèmes, Diderot Editeur Arts Sciences, 1996.
3. Bernard Pradin, Germain Garcia, Modélisation, analyse et commande des systèmes linéaires Presse universitaires du Mirail, 2009.
4. Edouard Laroche, Bernard Bayle, Optimal Control, handout, 2007-2008

5. Pierre-Olivier Malaterre, Modélisation, analyse et commande optimale LGR d'un canal d'irrigation, Cemagref, 1994.
6. Maïtine Bergounioux, Optimisation et contrôle des systèmes linéaires : Cours et exercices corrigés, Dunod, 2001.

Semester: 2
Teaching unit: UEF 1.2.2
Subject: Applied electronics
VHS: 45h00 (Lectures: 1h30, DW: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Introduce the student to other main functions of electronics. The student must first be able to identify the type and function of an electronic component in a global system (even in industry). They must then be able to carry out measurements on an electronic circuit (possibility of• modifications or troubleshooting). They must be able to provide a solution to problem situations (design and build• analogue electronic circuits).

Previous knowledge recommended:

Students must have the following knowledge

- Fundamental electronics
- Power electronics

Subject content:

Chapter 1: Reminder of the switching transistor and charging and discharging a capacitor **(1 week)**

Chapter 2: The operational amplifier and AO-based circuits **(2 weeks)**

- Linear mode operation
- Non-linear operation

Chapter 3: Pulse (signal) generation **(3 weeks)**

-Astable (with AOP , with NE555 , with logic gates)

- Monostable (with AOP , with NE555 , with logic gates)

-Schmitt trigger (AOP).

Chapter 4: CAN converter, CNA **(3 weeks)**

Chapter 5: Study of active filters **(2 weeks)**

Chapter 6: Introduction to PCB design principles **(4 weeks)**

- PCB manufacturing technology
- Production rules (routing, multi-layers)

Assessment method:

Continuous assessment: 40%; examination: 60%.

References:

1. Yves Granjon, Bruno Estibals, Serge Weber, Electronique - Tout le cours en fiches, Collection: Tout le cours en fiches, Dunod, 2015 .
2. Albert Paul Malvino, David J. Bates Principes d'électronique, Cours et exercices corrigés, 8th edition, Dunod, 2016.
3. Charles Adams Platt, Xavier Guesnu, Eric Bernauer, Antoine Derouin, L'électronique en pratique : 36 expériences ludiques , Eyrolles, 2013.
4. François de Dieuleveult, Hervé Fane, Principes et pratique de l'électronique, tome 1: Calcul des circuits et fonctions, Dunod, 1997.

5. François de Dieuleveult, Hervé Fanet Principes et pratique de l'électronique, tome 2: Fonctions numériques et mixtes, Dunod, 1997.
6. Christophe François, Romain Dardevet, Patrick Soleilhac, Génie Électrique : Électronique Analogique Électronique Numérique Exercices et Problèmes Corrigés, Ellipses Marketing 2006.
7. Mohand Mokhtari Applied Electronics, Electromechanics under Simscape & Sim Power Systems (Matlab/Simulink), Springer-Verlag Berlin and Heidelberg GmbH & Co 2012.
8. P. Mayeux, "Learning electronics through experimentation and simulation", ETSF, 2006.

Semester: 2
Teaching unit: UEF 1.2.2
Subject 1: PLC and supervision
VHS: 45h00 (Lectures: 1h30, DW: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

At the end of the course, the student should be able to define the programming and supervision tools needed to create a control system based on a specification, and then choose the equipment and configuration needed to create the system. Design a program and implement an industrial automation system.

Previous knowledge recommended:

Students must have the following knowledge

- Programmable logic controllers.
- Programming

Subject content:

Chapter 1: Programmable logic controllers (3 weeks)
- CPU structure: architecture, memory.
- The different types of API data
- Digital input/output modules, - Analogue input/output modules, - Business modules
- PID control boards (Principle of PID control. - Different types of control loops (single, cascade, mixed))
- Axis control cards
- Quick count cards

Chapter 2: Programming languages: IEC 1131-3 standard (5 weeks)
-Wired logic
- Programmed logic
- Programming languages (LD, SFC, FBD, ST and IL)
- Arithmetic and logical operations

Chapter 3: Blocks and functions (3 weeks)
- Program memory organization, Data memory organization (mementos, DB).
- Program structure analysis
- Block concept
- Programming blocks of programs, functions, organization and data.

Chapter 4: Human-machine interface and supervision (4 weeks)
Introduction: Objectives of supervision

- Role and principle of **HMI**
- Data transmission between HMI and PLC CPU
- Transmission modes (parallel, serial, half or full duplex).

- Data transmission standards (BC20mA, RS232, RS422, MODEM, etc.)

Implementing TD 200 and S7-300 PLC communication

- Serial link cabling (problems, solutions, etc.)
- Example: Application on HMI (SIEMENS TD200 / OP3)

Configuration mode for different types of HMI

Terminal configuration

Implementation of an application, practical example ON HMI STANDARD EXOR GRAPHICS

Assessment method:

Continuous assessment: 40%; Examination: 60%.

References

1. Frank Petruzella LogixPro PLC Lab Manual for Programmable Logic Controllers 5th Edition, McGraw-Hill Education; 5 edition, 2016
2. Su Chen Jonathon Lin Programmable Logic Controllers Hardcover - July 20, 2016, Industrial Press; First Edition, Coursepack edition, 2016.
3. Dag H. Hanssen, Programmable Logic Controllers: A Practical Approach to IEC 61131-3 using CoDeSys 1st Edition, Wiley; 1 edition, 2015.
4. Samuel Guccione, James McKirahan Human Machine Interface: Concepts and Projects, Industrial Press, Inc (June 1, 2016.
5. Khaled Kamel, Eman Kamel Programmable Logic Controllers: Industrial Control 1st Edition, McGraw-Hill Education; 1 edition, 2013.
6. William Bolton, "Les automates programmables industriels", 2e ed, Dunod, 2015.
7. Manual, SIMATIC HMI WinCC, Volume 1 / 2, Edition August 1999
8. SIMATIC HMI Device TP 177A, TP 177B, OP 177B (WinCC flexible) Operating Instructions, Siemens, Edition, 2008.

Semester: 2
Teaching unit: UEM 1.2
Subject: Concepts and language of graphic programming
VHS: 37h30 (lectures: 1h30, practical work: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives

This course will familiarise the student with the LabVIEW graphical programming environment and basic LabVIEW functionality for building data acquisition and instrument control applications.

Previous knowledge recommended:

Students must have the following knowledge

- Programming basics

Subject content:

Chapter 1: Introduction to LabVIEW virtual instruments, LabVIEW vocabulary, LabVIEW environment, LabVIEW application components, LabVIEW programming tools
(2 weeks)
Chapter 2: Customizing a VI **(2 weeks)**
Chapter 3: Signal analysis and recording **(2 weeks)**
Chapter 4: Hardware: data acquisition and communication with instruments (Windows) **(2 weeks)**
Chapter 5: Loops, shift registers and Loops, shift registers and introduction to graphics, Tables and files, Functions of tables and Functions of tables and graphics **(4 weeks)**
Chapter 6: Character strings, clusters and Character strings, clusters and error handling, Condition and Sequence structures, Calculation box and Variables **(3 weeks)**

PW LabVIEW :

PW 1: Introduction to programming
PW 2: LabVIEW calculations
PW 3: Signal acquisition and generation
PW 4: Loops and structures
PW 5: Tables and graphs
PW 6: Character strings
PW 7: Communication with an instrument

Assessment method:

Continuous assessment: 40%; Examination: 60%.

References

1. Francis Cottet, Michel Pinard, Luc Desruelle, LabVIEW, Programming and applications, 3rd edition, Dunod/L'Usine Nouvelle, 2015.
2. Nadia Martaj, Mohand Mokhtari, Learning and mastering LabVIEW through its applications, Springer, 2014.
3. Thierry Royant LabVIEW, Bases de programmation et applications, Casteilla, 2005.
4. Robert H. Bishop, LabVIEW 2009 Student Edition, Prentice Hall, 2009.

***Semester* 2**
Teaching unit : UEM1.2
Subject: PW Nonlinear systems/ PW Optimal control
VHS: 22h30 (PW: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

PW NLS: Demonstrate the difference between the dynamic behaviour of linear and non-linear systems. Demonstrate the concept of an equilibrium point. Use simulation to show the importance of the phase plane. Synthesis of non-linear systems.

TP Optimal control, enabling students to use and master the theoretical concepts studied in the course.

Recommended prior knowledge

Matlab/Simulink. Principles of physics for modelling mechanical, electrical, hydraulic, pneumatic and robotic systems, etc.

Contents of Nonlinear systems:

PW 1: Advanced simulation on Matlab
PW 2: Simulating the equilibrium points of a few non-linear systems
PW 3: Simulation of some non-linear systems in the phase plane
PW 4: Open-loop inverse pendulum simulation
PW 5: Linearising control simulation
PW 6: Sliding mode control

Contents of Optimal control:

PW1: Introduction to Matlab
PW1: State feedback control and observers
PW 2: Minimum-time optimal control.
PW 3: Linear-quadratic control, applications to regulation
PW 4: Numerical methods in optimal control

Assessment method: 100% continuous assessment

Semester: 2
Teaching unit: UEM 1.2
Subject: PW Applied electronics
VHS: 22h30 (PW: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives

The aim of the practical work is to give students the opportunity to create electronic assemblies on a test board and then validate their operation using measurement equipment.

Recommended prior knowledge

Course content.

Contents of the subject PW Applied electronics :

PW 1: Study of the FET and MOS field effect transistor amplifier :
PW 2: Operational amplifiers
PW 3: Study of an example of a CAN circuit, Study of an example of a DAC circuit.
PW 4: Oscillators
PW 5: Active filters (low-pass, high-pass, etc.)
PW6: Building an electronic assembly :
Both the subject leader and the student are free to propose the creation of other montages.

Assessment method: 100% assessment

Semester: 2

Teaching unit: UEM 1.2
Subject: PW PLC and supervision
VHS: 22h30 (PW: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives

This practical work will enable the student to put into practice and consolidate the knowledge acquired in the PLC and supervision module.

Recommended prior knowledge

Course content

Subject content:

Plan some practical work with the equipment available.

Assessment method: 100% assessment

Semester: 2
Teaching unit : UET 1.2
Subject: Compliance with standards and rules of ethics and integrity.
VHS: 22:30 (Course: 1:30)
Credit : 1
Coefficient: 1

Teaching objectives:

Raising students' awareness of the ethical principles and rules that govern life at university and in the world of work. Make them aware of the need to respect and value intellectual property. Explain to them the risks of moral evils such as corruption and how to combat them, and alert them to the ethical issues raised by new technologies and sustainable development.

Recommended prior knowledge:

Ethics and professional conduct (the basics)

Contents :

A.Respect for the rules of ethics and integrity,

1. **Reminder of the MESRS Charter of Ethics and Professional Conduct:** Integrity and honesty. Academic freedom. Mutual respect. Requirement of scientific truth, Objectivity and critical spirit. Fairness. Rights and obligations of students, teachers, administrative and technical staff,

2. Research with integrity and responsibility

- Respect for ethical principles in teaching and research
- Teamwork responsibilities: Equal treatment in the workplace. Combating discrimination. Looking after the general interest. Inappropriate behaviour in the context of teamwork
- Adopting responsible conduct and combating abuses: Adopting responsible conduct in research. Scientific fraud. Conduct to combat fraud. Plagiarism (definition of plagiarism, different forms of plagiarism, procedures to avoid unintentional plagiarism, detection of plagiarism, sanctions against plagiarists, etc.). Falsification and fabrication of data.

3. Ethics and deontology in the world of work :

Legal confidentiality within the company. Loyalty to the company. Responsibility within the company, Conflicts of interest. Integrity (corruption in the workplace, its forms, consequences, methods of combating it and sanctions).

B- Intellectual property

I- Fundamentals of intellectual property

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

II- Copyright

1. Copyright in the digital environment

Introduction. Database copyright, software copyright and the specific case of open source software.

2. Copyright on the Internet and e-commerce

Domain name law. Intellectual property on the Internet. E-commerce site law. Intellectual property and social networks.

3. Patent

Definition. Rights in a patent. Usefulness of a patent. Patentability. Patent applications in Algeria and worldwide.

III- Protecting and promoting intellectual property

How to protect intellectual property. Infringement of rights and legal tools. Enhancing the value of intellectual property. Protection of intellectual property in Algeria.

C. Ethics, sustainable development and new technologies

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

Assessment method :

Examination: 100

References:

1. Charter of university ethics and deontology, https://www.mesrs.dz/documents/12221/26200/Charte+fran__ais+d__e.pdf/50d6de61-aabd-4829-84b3-8302b790bdce
2. Order No. 933 of 28 July 2016 laying down rules on preventing and combating plagiarism
3. Copyright Primer, United Nations Educational, Scientific and Cultural Organization (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. and 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, 2nd quarter 2002, n°94.
11. Jacquet-Francillon, François. Notion : déontologie professionnelle. Le télémaque, May 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. The engineer at the heart of innovation. Belfort-Montbéliard University of Technology
17. Fanny Rinck and léda Mansour, Literacy in the digital age: copying and pasting among students, Université grenoble 3 and Université paris-Ouest Nanterre la défense Nanterre, France
18. Didier DUGUEST IEMN, Citing sources, IAE Nantes 2008
19. Similarity detection software: a solution to electronic plagiarism? Report of the Working Group on Electronic Plagiarism presented to the CREPUQ Subcommittee on Pedagogy and ICT
20. Emanuela Chiriac, Monique Filiatrault and André Régimbald, Guide de l'étudiant: l'intégrité intellectuelle plagiat, tricherie et fraude... les éviter et, surtout, comment bien citer ses sources, 2014.
21. Université de Montréal publication, Strategies for preventing plagiarism, Integrity, fraud and plagiarism, 2010.

22. Pierrick Malissard, Intellectual property: origin and evolution, 2010.
23. The World Intellectual Property Organization website www.wipo.int
24. http://www.app.asso.fr/

III - Detailed syllabus by subject for semester S3

Semester: 3
Teaching unit: UEF 2.1.1
Topic 1: Predictive and adaptive control
VHS: 67h30 (Classes: 3h00, Workshops: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:

This course consists of two parts. The first part deals with predictive control, presenting the different types of this control and their implementation. The second part deals with adaptive control, presenting the essential elements for implementing this control.

Previous knowledge recommended:

Students must have the following knowledge

- Linear servo systems
- Non-linear servo systems

Subject contents:

Predictive control
Chapter 1: Principles of predictive control (1 week)
Chapter 2: Generalized Predictive Control (3 weeks)
Prediction model, optimal predictor. Minimisation of a quadratic cost function with a finite horizon. Synthesis of the equivalent RST polynomial controller. Choice of tuning parameters, compromise between stability, performance and robustness. GPC under constraints.

Chapter 3: Predictive control based on state models (3 weeks)
Prediction model, optimal predictor. Minimisation of a quadratic cost function with a finite horizon, constrained MBPC.

Adaptive control
Chapter 1: The different adaptive control methods (3 weeks)
Pre-programmed gain control. Direct adaptive control with reference model. Indirect adaptive control with model identification.
Chapter 2: Implementation of adaptive control (3 weeks)
Controller structure. Continuous and discrete direct adaptive structure. Control laws of an indirect adaptive structure. Stability of an adaptive scheme. Robustness and robustness of an adaptive scheme.
Chapter 3: Identification in adaptive control (2 weeks)
Identification structures and algorithms: gradient, least squares. Identifier stability, permanent excitation condition. Convergence of parameters.

Assessment method:

Continuous assessment: 40%; Examination: 60%.

References

1. Aström, K., and Wittenmark, B., (1989). "Adaptive Control , Addison-Wesley Editions.
2. Bitmead, R.R., Gevers, M. and Wertz, V., (1990). "Adaptive Optimal Control. The Thinking Man's GPC, Prentice Hall International, Systems and Control Engineering.
3. Boucher, P., and Dumur, D., (1996). "La Commande Prédictive", Éditions Technip, Paris.
4. Isermann, R., Lachmann, K. H., and Matko, D. (1992). "Adaptive control systems", Prentice Hall.
5. Richalet, J., (1993). "Pratique de la Commande Prédictive". Hermès.
6. R. Isermann, Fault-Diagnosis Systems - An Introduction from Fault Detection to Fault Tolerance. Springer, 2006.
7. E. F. Camacho and C.Bordons Alba, Model Predictive Control, Springer 2004.
8. M. Alamir, A Pragmatic Story of Model Predictive Control: Self-Contained algorithms and case-studies, Create Space, 2013.

Semester: 3
Teaching unit: UEF 2.1.1
Material: Intelligent control
VHS: 45h00 (Lectures: 1h30, DW: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives

To present the methods and tools needed to integrate fuzzy logic and neural networks into industrial process identification and control schemes. To provide a theoretical basis that is essential for understanding these approaches and for using them in the analysis, synthesis and implementation phases.

Previous knowledge recommended:

Students must have the following knowledge

- Linear servo systems
- Sampled systems ;

Subject content:

Part I: Fuzzy logic :

Chapter 1: Introduction to fuzzy set theory **(1 week)**
Chapter 2: Fuzzy reasoning **(1 week)**
Chapter 3: Fuzzy modelling and fuzzy inference systems **(2 weeks)**
Chapter 4: Fuzzy control **(3 weeks)**

Part II: Neural networks

Chapter 1: Introduction to neural networks **(1 week)**
Chapter 2: Modelling (Mac Culloch and Pitts model, General modelling, The perceptron, Learning algorithms/techniques) **(3 weeks)**
Chapter 3: Multilayer networks **(3 weeks)**
Chapter 4. Application of neural networks **(1 week)**
.

Assessment method

Continuous assessment: 40%; examination: 60%.

References:

7. Isabelle Borne, Introduction à la commande floue, Technip, 1998
8. Louis Gacogne, Eléments de logique floue, Hermès - Lavoisier, 1997.
9. B. Bouchon-Meunier, L. Foulloy, M. Ramdani Logique floue : Exercices corrigés et exemples d'applications, Cépaduès, 1998
10. J. Harris, An Introduction to Fuzzy Logic Applications, Springer, 2000.
11. George J. Klir, Bo Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall; 1st edition, 1995.
12. P. Borne, M. Benrejeb, J. Haggège, Les réseaux de neurons: Présentation et applications, Technip, Collection: Méthodes et pratiques de l'ingénieur, 2007
13. Gérard Dreyfus, Manuel Samuelides, Jean-Marc Martinez, Mirta B. Gordon, Fouad Badran, Sylvie Thiria, Laurent Hérault, Réseaux de neurones : Méthodologie et applications, Eyrolles (2nd edition), 2004.
14. Alain Faure, Classification et commande par réseaux de neurones, Hermès - Lavoisier, 2006

Semester:3
Teaching unit: UEF 2.1.2
Subject: Control of handling robots
VHS: 45h00 (Lectures: 1h30, DW: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives :

The aim of this subject is to enable students to master the modelling tools and control techniques for manipulator robots. It aims to give students the opportunity to undertake independently the resolution of a certain number of elementary robotics problems such as configuration, trajectory generation, dynamic control, etc.

Recommended prior knowledge:

- Linear automation and servo control.
- Basic notions of kinematics and dynamics.

Contents :

I-Introduction (1 week)

- 1. Definition and background
- 2. Different categories of robot
- 3. Robotics vocabulary
- 4. Characterisation of robots
- 5. The different types of robot manipulator
- 6. Use of robots
- 7. The future of robotics

II- Theoretical foundations and preliminary mathematics (2 weeks)

- 1. Positioning
  - 1.1 Rotation
  - 1.2 Rotation representations
  - 1.3. Attitude
  - 1.4. Homogeneous transformation matrices
- *2.* Kinematics
  - 2.1. Velocity of a solid
  - 2.2. Rotation speed vector
  - 2.3. Rigid motion
  - 2.4. Kinematic torsor and speed composition

III- Modelling a robot manipulator (3 weeks)

- 1. Geometric model
  - -Denavit-Hartenberg Convention
  - - Direct geometric model
  - - Inverse geometric model
- 2. Kinematic model
  - -Direct analysis (using the Jacobian direct)
  - -Inverse analysis (using the inverse Jacobian)
  - -Notion of Singularity
- 3. Dynamic model
  - -Formalisms for dynamic modelling
  - -Lagrange method: Lagrange equation, matrix representation (inertia matrix, Coriolis matrix, gravity matrix).
    - - Example (1 or 2DDL planar robot)

IV- Path generation (3 weeks)

- trajectory generation and control loops
- point-to-point motion generation: basic method, acceleration profile method, velocity profile method, application in joint space, application in Cartesian space.
- Motion generation by interpolation: application in joint space and Cartesian space

V- Robot control (3 weeks)

- 1. Dynamic control
- 2. Sliding mode control

VI- Robot programming (3 weeks)

- 1. Generalities and objectives of programming systems
- 2 . Programming methods
- 3. Characteristics of the different programming languages

Assessment method :

Continuous assessment: 40%; Examination: 60%.

References:

1. Philippe Coiffet, La robotique, Principes et Applications, Hermès, 1992.
2. Reza N. Jazar, Theory of Applied Robotics, Kinematics, Dynamics and Control. Springer 2007.
3. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, Robot Modeling and Control, Wiley, 1989.
4. Bruno Siciliano et al, Robotics, Modelling planning and Control, Springer, 2009.
5. W. Khalil & E. Dambre, modélisation, identification et commande des robots, Hermès, 1999.

Semester: 3
Teaching unit: UEF 2.1.2
Subject 1: System diagnosis
VHS: 45h00 (Lectures: 1h30, DW: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The aim of this course is to study the various diagnostic methods that consist of fault detection and isolation, with particular emphasis on model-based and model-free methods. We will show how we can increase the performance of dynamic systems by guaranteeing better reliability.

Previous knowledge recommended:
Students must have the following knowledge

- Continuous servo systems.
- Sampled systems

Subject content:

Chapter 1: Generalities and Definitions (1 week)

Analysis of the term "diagnosis", with a reminder of the terminology adopted for the various terms related to diagnosis, and definitions of the various stages in an industrial diagnosis procedure.

Chapter 2. Diagnostic methods. (3 weeks)

An overview of the different methods of fault diagnosis. The various methods have been classified into two categories: model-based methods and artificial intelligence-based methods.

Chapter 3: Residue generation by state observers (3 weeks)

We are developing a technique for detecting and locating sensor and actuator faults based on Luenberger, Kalman and Unkown Input Observers.

Chapter 4: Residue generation by parity space. (3 weeks)

Residue generation for the detection and isolation of sensor and actuator faults using analytical redundancy based on the notion of parity space.

Chapter 5. Diagnosis by parametric identification (3 weeks)

We are developing a parametric identification diagnostic method based on the Auto-regressive Averaging Model (ARMA), with a view to detecting system faults.

Chapter 6. Residue analysis (2 weeks)

Analysis of the residuals generated by statistical tests (Page-Hinkly) with a view to making a decision as to the presence or absence of a malfunction

Assessment method:

Continuous assessment: 40%; Examination: 60%.

References

9. S. Gentil (Ed.), "Supervision des procédés complexes", HERMES Systèmes automatisés, 2007.
10. Rolf Isermann, "Fault diagnosis systems", Springer, 2006.
11. Blanke, Kinnaert, Lunze, Staroswiecki, "Diagnosis and fault tolerant control", Springer, 2003.
12. Sylviane Gentil, Supervision of complex processes - Hermes Science Publications, 2007
13. Korbicz, Józef, Kościelny, Jan Maciej , Modeling, Diagnostics and Process Control: Implementation in the DiaSter System, Springer-Verlag Berlin Heidelberg, 2011.

Semester: 3
Teaching unit: UEM 2.1
Subject: Real-time systems
VHS: 37h30 (lectures: 1h30, practical work: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives

The objective of this course is to present the concepts that will enable students to analyse the requirements of a real-time problem, design the solution, demonstrate the correctness of the proposed design, program the solution, validate the solution, and design applications on a real-time system.

Previous knowledge recommended:

Students must have the following knowledge

- Basic knowledge of how microprocessors work.
- Knowledge of C programming.
-

Subject content:

Chapter 1: **Introduction to real-time systems**
Classification of real-time systems (hard, firm, soft real-time), structure of a real-time system, schedulability test, notions of thread, primitives, pseudo-parallelism**, etc.** **(2 weeks)**

Chapter 2: Architecture and operation of a real-time kernel (tasks, interrupts, etc.
(3 weeks)

Chapter 3: TR system specification techniques **(3 weeks)**
Scheduling techniques (SRTF, SJF, Round-Robin, ...), Selection criteria, Rate Monotoring algorithm, applications

Chapter 4: Concurrent programming **(3 weeks)**
Notion of deadlock, mutual exclusion by semaphore, synchronisation by event, communication, Presentation of sceptre, examples of real-time cores (VRTX, OS9, Vxworks, etc.).

Chapter 5: Programming language in TR **(4 weeks)**
Java, ADA, MODULA II

PW LabVIEW :

PW 1: Introduction to programming
PW 2: Task management
PW 3: Interruptions, signals, events
PW 4: Scheduling
PW 5: Synchronization and communication
PW 6: Time management

Assessment method:

Continuous assessment: 40%; Examination: 60%.

References

5. Francis Cottet, Emmanuel Grolleau, Sébastien Gérard, Jérome Hugues, Yassine Ouhammou, Embedded real-time systems: specification, design, implementation and temporal validation, -2nd edition, Dunod, 2014.
6. Francis Cottet, Emmanuel Grolleau, Systèmes temps réel de contrôle-commande : Conception et implémentation Relié, Dunod, 2005.
7. B. Nichols, D. Buttlar, J. Proulx Farrel, O'Reilly, Pthreads programming, (1996)
8. Maryline Chetto, Scheduling in real-time systems, ISTE, 2014.
9. Jane W. S. Liu, "Real-time Systems", Prentice Hall, 2000
10. Christian Bonnet. Isabelle Demeure, Introduction aux systèmes temps réel. Collection pédagogique de télécommunications, Hermès, September 1999.
11. A. Dorseuil and P. Pillot. Le temps réel en milieu industriel. Edition DUNOD, Collection Informatique Industrielle, 1991.

Semester 3
Teaching unit : UEM 2.1
Subject : PW Predictive and adaptive control/PW Intelligent control
VHS: 22h30 (PW: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

To enable students to use and master the theoretical concepts studied in the course.

Recommended prior knowledge

Course content.
Matlab/Simulink.

Contents of Predictive and adaptive control :

PW 1: Generalized Predictive Control

PW 2: Predictive control based on state models

PW 3: Predictive Control

PW 4: Control with pre-programmed gains and self-adjustment

PW 5: Direct and indirect adaptive control

PW 6: Adaptive closed-loop control

Contents of Intelligent control :

PW 1: Modelling a dynamic system using logic
PW 2: Fuzzy control of a dynamic system
PW 3: Fuzzy PID control of a system
PW 4: Modelling a dynamic system using neural networks
PW 5: Neural control of a dynamic system
PW 6: Multi-layer neural control of a dynamic system

Assessment method: 100% continuous assessment

Semester: 3
Teaching unit: UEM 2.1
Subject: PW System diagnosIs
VHS: 22h30 (PW: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives

The aim of the practical work is to give students the opportunity to introduce the concepts of fault detection and diagnosis of complex systems. Apply different types automatic diagnosis methods that have proved their worth in different applications.

Recommended prior knowledge

Course content.

Contents of the subject PW System diagnosis :

PW 1: Designing a system and adapting it for diagnosis.
PW 2: Detecting faults using a Luenberger observer**.**
PW 3: Detecting and locating faults using observer banks with unknown inputs.
PW 4: Generating residuals using analytical redundancy.
PW 5: Diagnosis using parametric identification
PW 6: Analysis of residuals using the Page-Hinkley test

Assessment method: 100% assessment

Semester: 3
Teaching unit: UEM 2.1
Subject: PW Control of handling robots
VHS: 22h30 (PW: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives

To put into practice and give a concrete aspect to the concepts seen in the "Control of handling robots" course through practical work to better understand and assimilate the content of this subject.

Recommended prior knowledge

Course content

Subject content:

PW 1: Introduction to Matlab Robotics Toolbox. (Geometric transformations)

PW 2: Geometric and inverse modelling of a Plan robot (3DDL).

PW 3: Direct and inverse kinematic modelling.

PW 4: Dynamic modelling of a planar robot (2DDL).

PW 5: Generation of trajectories in articular and Cartesian mode.

PW 6: Dynamic robot control

Assessment method: 100% assessment

Semester: 3
Teaching unit: UET 2.1
Subject 1: Documentary research and dissertation design
VHS : 22h30 (Class: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives :
To give students the tools they need to find useful information and put it to better use in their end-of-studies project. Help them through the various stages involved in writing a scientific document. To emphasise the importance of communication and to teach students how to present their work in a rigorous and educational manner.

Recommended prior knowledge:
Writing methodology, Presentation methodology.

Subject content:

Part I : Documentary research :

Chapter I-1: Definition of the subject **(02 Weeks)**
- Subject heading
- List of keywords relating to the subject
- Gather basic information (acquisition of specialist vocabulary, meaning of terms, linguistic definitions)
- Information sought
- Take stock of your knowledge in the field

Chapter I-2: Selecting sources of information **(02 Weeks)**
- Type of document (books, theses, dissertations, periodical articles, conference proceedings, audiovisual documents, etc.)
- Type of resources (libraries, Internet, etc.)
- Assessing the quality and relevance of information sources

Chapter I-3: Locating documents **(01 Week)**
- Search techniques
- Search operators

Chapter I-4: Processing information **(02 Weeks)**
- Organisation of work
- The initial questions
- Summary of documents selected
- Links between different parts
- Final plan for documentary research

Chapter I-5: Presentation of the bibliography **(01 Week)**
- Systems for presenting a bibliography (Harvard system, Vancouver system, mixed system, etc.)
- Presentation of documents.
- Quoting sources

Part II: Memory design

Chapter II-1: Plan and stages of the dissertation **(02 weeks)**

- Identifying and defining the subject (Summary)
- Issues and objectives of the dissertation
- Other useful sections (Acknowledgements, Table of abbreviations, etc.)
- The introduction (*Writing the introduction last*
- Specialist literature
- Formulation of hypotheses
- Methodology
- Results
- Discussion
- Recommendations
- Conclusion and outlook
- Table of contents
- Bibliography
- The appendices

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

- Formatting. Numbering chapters, figures and tables.
- The cover page
- Typography and punctuation
- Writing. Scientific language: style, grammar, syntax.
- Spelling. Improving general language skills in terms of comprehension and expression.
- Backing up, securing and archiving data.

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

Chapter II-4: Oral presentations and defences **(01 Week)**

- How to present a Poster
- How to present an oral communication.
- Defending a dissertation

Chapter II-5: How to avoid plagiarism? **(01 Week)**

(Formulas, sentences, illustrations, graphs, data, statistics, etc.)

- The quote
- Paraphrasing
- Indicate the complete bibliographical reference

Assessment method :

Examination: 100%.

References :

1. *M. Griselin et al, Guide de la communication écrite, 2nd edition, Dunod, 1999.*
2. *J.L. Lebrun, Guide pratique de rédaction scientifique : comment écrire pour le lecteur scientifique international, Les Ulis, EDP Sciences, 2007.*
3. *A. Mallender Tanner, ABC de la rédaction technique : modes d'emploi, 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*