PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA

MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

MASTER TRAINING OFFER

ACADEMIC

Establishment	Faculty	Department
University of Khemis-Miliana	Science and Technology	Mathematics and Computer Science

Field: Mathematics and Computer Science

Branch: Mathematics

Speciality: Mathematical Analysis and Applications

Academic year: 2016-2017

الجمهورية الجزائرية الديمقراطية الشعبية
وزارة التعليم العالي و البحث العلمي

مواءمة

عرض تكوين ماستر

أكاديمي

القسم	الكلية	المؤسسة
رياضيات وإعلام الالي	العلوم والتكنولوجيا	جامعة خميس مليانة

الميدان: رياضيات وإعلام الالي
الشعبة: رياضيات
التخصص: تحليل رياضي و تطبيقات

السنة الجامعية:2016-2017

SUMMARY

I – Identity card of the Master

(All fields must be filled in)

1. Location of the training:

Faculty: Science and Technology.

Department: Mathematics and Computer Science.

2. Training Partners*:

- **Other university establishments**: None.

- **Companies and other socio-economic partners:** None.

- **International partners:** None.

3. Context and objectives of the training

A. Conditions of access

Access to the Master is open to students holding a bachelor's degree in "Mathematics-Computer Science" with a "Mathematics" track, or any other equivalent bachelor's degree or diploma in Mathematics, depending on the places available.

B. Training objectives

This Master offers in-depth training in areas related to pure and applied mathematics. The laureates can ensure teaching tasks at the secondary and university level. They can also apply for a doctorate in Mathematics, particularly in Classical Analysis, Ordinary Differential Equations, Partial and Fractional Derivatives, as well as image processing and artificial vision.

C. Targeted business profiles and skills

- Acquisition of in-depth and solid knowledge in pure (differential equations) and applied (optimization, scientific calculation, and image processing and computer vision) mathematics.

- Introduction to scientific research: research approach, capacity for abstraction, autonomy, spirit of synthesis, ...

- Learning to write and mathematical presentation: scientific approach and computer tools.

D. Regional and national employability potential of graduates

At the end of the training, students can either continue their studies in a doctoral thesis in mathematics, or move towards careers in teaching and/or research (fundamental or applied) in universities and organizations. appropriate. The lack of teachers and researchers in Mathematics in the central and western region of Algeria offers wide employability opportunities to the graduates of this Master's degree in Mathematics.

E – Gateways to other specialties

F – Training monitoring indicators

- Success rate in M1 and M2.

- Number of students enrolled in PhD.

- Number of students recruited at the end of the training.

G – Supervisory capacity

25 students in M1.

This will subsequently depend on the evolution of the framework in terms of the number and specialty of teachers working within the department, but also on their availability.

4 – Moyens humains disponibles

A : Enseignants de l'établissement intervenant dans la spécialité :

Nom, prénom	Diplôme graduation + Spécialité	Diplôme Post graduation + Spécialité	Grade	Type d'intervention *	Emargement
Benbachir Maamar	Magister, Systèmes dynamiques	Doctorat d'état, Systèmes dynamiques	Prof.	Cours, Td, Encadrement	
Chaouchi Belkacem	Magister, EDP	Doctorat, EDP	MCB	Cours, Td, Encadrement	
Diaf Ahmed	Doctorat, Phy théorique	HDR, Phy théorique	MCA	Cours, Td, Encadrement	
Hachama Mohamed	Doctorat, Math. appliquées	HDR, Math. appliquées	MCA	Cours, Td, Encadrement	
Boukebcha Hocine	Magister, Phy théorique	Doctorat, Phy théorique	MCB	Cours, Td, Encadrement	
Hachichi Hiba	Magister, Informatique	Doctorat, Informatique	MCB	Cours, Td, Encadrement	
Benniche Omar	DES, EDO	Magister, Systèmes Dynamqiues	MAA	Cours, Td, Encadrement	
Said Abderrazak	Licence, EDP	Magister, EDP	MAA	Cours, Td, Encadrement	
Djouamai Lella	DES, EDP	Magister, EDP	MAA	Cours, Td, Encadrement	
Boukedroun Mohamed	DES, Statistique	Magister, RO	MAA	Cours, Td, Encadrement	
Chitta Fouzia	DES Edp	Magister, EDP	MAA	Cours, Td, Encadrement	
Houas Mohamed	DES, RO	Magister, RO	MAA	Cours, Td, Encadrement	
Bezziou Mohamed	DES, EDP	Magister, EDP	MAA	Cours, Td, Encadrement	
Meghatria Farida	Ingénieur, RO	Magister, RO	MAA	Cours, Td, Encadrement	
Saadaoui Boualem	DES, Algèbre	Magister, Algèbre	MAA	Cours, Td, Encadrement	
Yache abdelkader amin	DES, EDO	Magister, EDO	MAA	Cours, Td, Encadrement	
Krelifa ali	DES, EDP	Magister, EDP	MAA	Cours, Td, Encadrement	

* = Cours, TD, TP, Encadrement de stage, Encadrement de mémoire, autre (à préciser)

B: External framing:

Attached institution:

Last name First Name	graduation diploma + Specialty	Post-graduation diploma+ Specialty	Grade	Type of intervention *	sign-in
None	**None**	**None**	**////////**	**////////////////////////**	**////////////////////////**

***** = Courses, TD, TP, Internship supervision, Memory supervision, other (to be specified)

5 – Specific material resources available

A- Pedagogical Laboratories and Equipment: Sheet of existing pedagogical equipment for the practical work of the planned training (1 sheet per laboratory)

Lab title: Computer Science

N°	Equipment name	Number	observations
	Microcomputer	40 posts	
	Internet	40 posts	
	Audio visual equipment (language)	1 room	
	Library	1 room	

B- Internship sites and in-company training:

Lieu du stage	Nombre d'étudiants	Durée du stage

C- Laboratoire(s) de recherche de soutien au master :

Chef du laboratoire : BENALLAL Mohamed Nadjib

N° Agrément du laboratoire : 2/ Année 2009

Date : 25/04/2016

Avis du chef de laboratoire :

Avis favorable

D- Projet(s) de recherche de soutien au master :

Intitulé du projet de recherche	Code du projet	Date du début du projet	Date de fin du projet
Réductions de systèmes différentiels et applications	C00L03UN220120130035	01/01/2014	31/12/2017
Etudes théorique et numérique de quelques EDP et applications	C00L03UN440120130032	01/01/2014	31/12/2017

E- Espaces de travaux personnels et TIC :

- 1 bibliothèque centrale.
- 2 salles de lecture.
- 2 salles d'informatique et d'internet.

II – lesson organization sheet of semester1

(Please submit the sheets for the 4 semesters)

1- Semester 1:

Teaching unit	VHS	V.H weekly				Coeff	Credits	Method Evaluation	
	14-16 sem	C	TD	TP	Personal work			Continu	Examen
Fundamental Teaching Units						**9**	**18**		
FTU1.1									
FTU1.1.1 : Topology and Functional Analysis	63h	3h	1h30		6h	3	6	40 %	60 %
FTU1.1.2 : Distribution Theory	42h	1h30	1h30		4h	2	4	40 %	60 %
FTU1.2									
FTU1.2.1: Introduction to image processing	42h	1h30	1h30		4h	2	4	40 %	60 %
FTU1.2.2: Ordinary differential equations	42h	1h30	1h30		4h	2	4	40 %	60 %
Methodology Teaching Unit						**5**	**9**		
MTU1									
MTU1.1: Continuous optimization	63h	1h30	1h30	1h30	3h	3	5	40 %	60 %
MTU1.2: Scientific calculation	42h		1h30	1h30	3h	2	4	100 %	
Transversal Teaching Unit						**2**	**3**		
TTU1									
TTU1.1 : Basic English	21h		1h30		3h	1	2		100 %
TTU1.2 : Scientific communication	21h			1h30	2h	1	1	100 %	
Total Semester 1	**336h**	**9h**	**10h30**	**4h30**	**29h**	**16**	**30**		

2- Semester 2:

Teaching unit	VHS	V.H weekly				Coeff	Crédits	Method Evaluation	
	14-16 sem	C	TD	TP	Personal work			Continu	Examen
Fundamental Teaching Units						**9**	**18**		
FTU2.1									
FTU2.1.1: Fourier analysis	63h	3h	1h30		5h	3	6	40 %	60 %
FTU2.1.2: Holomorphic and meromorphic functions	42h	1h30	1h30		4h	2	4	40 %	60 %
FTU2.2									
FTU2.2.1: computer vision	42h	1h30	1h30		5h	2	4	40 %	60 %
FTU2.2.2: Differential inclusions	42h	1h30	1h30		5h	2	4	40 %	60 %
Methodology Teaching Unit						**5**	**9**		
MTU2									
MTU2.1: Convex optimization	63h	1h30	1h30	1h30	5h	3	5	40 %	60 %
MTU2.2: Fractional calcul	42h	1h30	1h30		3h	2	4	40 %	60 %
Transversal Teaching Unit						**2**	**3**		
TTU2									
TTU2.1: Scientific English	21h		1h30		2h	1	2		100 %
TTU2.2: Corruption and Work Ethics	21h	1h30			2h	1	1		100 %
Total Semester 2	**336h**	**12h**	**10h30**	**1.30h**	**31h**	**16**	**30**		

3- Semester 3 :

Teaching unit	VHS	V.H hebdomadaire				Coeff	Crédits	Mode d'évaluation	
	14-16 sem	C	TD	TP	Autres			Continu	Examen
Fundamental Teaching Units						**9**	**18**		
FTU3									
FTU3.1 : Spectral theory of operators and semigroups	63h	3h	1h30		3h	3	6	40 %	60 %
FTU3.2 : Fractional Differential Equations	63h	3h	1h30		3h	3	6	40 %	60 %
FTU3.3 : Advanced models for image processing	63h	3h	1h30		3h	3	6	40 %	60 %
Methodology Teaching Unit						**5**	**9**		
MTU3									
MTU3.1 : Differential inclusion and optimal control	63h	3h	1h30		2h	3	6	40 %	60 %
MTU3.2 : Numerical analysis for differential equations	42h	1h30	1h30		2h	2	3	40 %	60 %
Transversal Teaching Unit						**2**	**3**		
TTU3									
TTU3.1 : Scientific Calculus for Differential Equations	21h			1h30		1	2	100 %	
TTU3.2 : Seminar	21h		1.30h		8h	1	1	100 %	
Total Semester 3	**336h**	**13h30**	**9h**	**1h30**	**21h**	**16**	**30**		

4- Semester 4:

Field: Mathematics and Computer Science

Branch: Mathematics

Speciality: Mathematical Analysis and Applications

A research project will be proposed to each student. The work will be supervised by a teacher and sanctioned by a memory and a defense.

Teaching unit	VHS	Coeff	Crédits
FTU4 : Mémory	330h	16	30
Total Semester 4	330h	16	30

5- Global summary of the training: (indicate the separate global VH in progress, TD, for the 04 teaching semesters, for the different types of EU)

UE VH	FTU	MTU	TTU	DTU	Total
Cours	378h	84h	42h	00	**504h**
TD	210h	84h	42h	00	**336h**
TP	00	105h	0h	00	**105h**
Personal work	364h	210	90h	00	**664h**
Mémory	330	00	00	00	**700h**
Total	**1652h**	**483h**	**132h**	**00**	**2267h**
Crédits	86	26	08	00	**120**
% in credits for each teaching unit	71%	22%	7%	00	100%

III - Detailed program by subject

(1 detailed sheet per subject)

Title of the Master: Mathematical Analysis and Applications
Semester: S1
Unit title: FTU1.1.1
Subject title: Topology and Functional Analysis.
Credits: 06
Coefficients: 03

Teaching objectives: This subject teaches the basics of Banach spaces, the bounded operators acting on these spaces, as well as the rudiments of the spectral theory. The main theorems of Functional Analysis are introduced.
Recommended prior knowledge: Real Analysis and Linear Algebra at the undergraduate level.

Content of the course:
- Recall of topology and analysis
    - Continuity, Product topology, Suites of topological spaces,
    - . Compactness, Major theorems of functional analysis.
- Weak topology
    - Abstract framework
    - Weak topology
    - Examples
- Weak* topology.
    - Definition
    - Properties
    - A compactness result
- Reflexive spaces, separable spaces, uniformly convex spaces

Evaluation method : Exam (60%), continuous control (40%).

References :

• Brézis H., Analyse fonctionnelle. Masson, 1983.
• Kolmogorov A., Fomin S., Eléments de la théorie des fonctions et de l'analyse fonctionnelle.
Mir, 1974.

• Reed M., Simon B., Methods of modern mathematical physics, I. Functional analysis. Academic Press, 1980.
• Rudin W., Analyse réelle et complexe. Masson, 1980.
• Yosida K., Functional analysis. Springer, 1980.

Title of the Master: Mathematical Analysis and Applications
Semester: S1
Unit title: FTU1.1.2
Subject title: Distribution Theory
Credits: 04
Coefficients: 02
Teaching objectives: Schwartz distributions are introduced as well as the associated fundamental manipulations. The basic elements of Sobolev spaces are taught.

Recommended prior knowledge: Real Analysis and Linear Algebra at License level.

Content of the course:
Test-functions and convergence in D(Ω) (where Ω is an open set of Rn).
- Definition of a distribution. Order of a distribution. Distribution support. Compact support distributions.
- Convergence of distributions (convergence of sequences of distributions – convergence of series of distributions).
- Distribution Operations. Multiplication of distributions. Derivation of distributions. Properties and Examples.
- Convolution of distributions. Tensor product of distributions. Some properties of the tensor product. Properties of the convolution of distributions. Regularization of distributions.

Evaluation method: Exam (60%), continuous control (40%).

Référence :

- Bony J. M., Cours d.analyse. Théorie des distributions et analyse de Fourier. Ellipses, 2001.
- Friedlander G., Joshi M., Introduction to the theory of distributions. Cambridge University. Press. 1998.
- Hörmander L., Distribution theory and Fourier analysis. Springer, 2000.
- Zuily C., Distributions et équations aux dérivées partielles, exercices corrigés. Hermann, 1986.
- Zuily C., Eléments de distributions et équations aux dérivées partielles. Dunod, 2002.

Title of the Master: Mathematical Analysis and Applications
Semester: S1
Unit title: FTU1.2.1
Subject title: Introduction to image processing
Credits: 04
Coefficients: 02
Teaching objectives: This course is an introduction to image processing. It presents an overview of some fundamental subjects in image processing by showing simple mathematical techniques for processing them.
Recommended prior knowledge: Real analysis, linear algebra, Fourier analysis.
Content of the course:

- Introduction
• Image formation, acquisition, quantification, sampling, statistical properties.
- Geometric transformations and interpolation, Photometric transformations.
- Spatial processing
• Relations between pixels. Intensity transformations. Linear filtering. Nonlinear filtering.
- Frequency processing.
• Fourier transform. Convolution theorem. Frequency filtering. DCT. Wavelets.
- Catering
• Noise study. Linear filtering. Nonlinear filtering.
- Segmentation and edge detection
• Threshold/Classification. Growth of regions. Partition of regions. Grouping.
• Approaches based on the gradient and the Laplacian. Analytical approaches. Parametric method. Post-processing.

Evaluation method: Exam (60%), continuous control (40%).

Références :

- R.C. Gonzales, R.E. Woods, *Digital image processing*, Prentice Hall 2002.
- H. Maitre et al., *Traitement numérique des images*, Cours ENST, 2008.
- Richard Szeliski, Computer Vision: Algorithms and Applications, 2011, Springer-Verlag New York, Inc.

Title of the Master: Mathematical Analysis and Applications
Semester: S1
Unit title: FTU1.2.2
Subject title: Ordinary differential equations
Credits: 04
Coefficients: 02

Teaching objectives: The main objective of this course is to study Cauchy problems in Banach spaces of infinite dimension. Fixed point theory makes a very important tool. Some stability issues will also be investigated.

Recommended prerequisites: Classic undergraduate courses.

Content of the course:

- General information on differential equations.

• Notion of solution, type of solutions (local, maximum, global and saturated solution).

• Reminders on the theorems of existence and uniqueness of solutions in the finite dimension.

- On the theory of the fixed point.

- Existence of solutions of ordinary differential equations in the infinite dimension.

- Notion of stability

• General. Stability of linear differential systems. Lyapunov method.

Evaluation method: Exam (60%), continuous control (40%).

Références :

- I.I. Vrabie. Differential equations World scientific publishing. 2011.
- V.I. Arnold. Ordinary Differential equations. Published by Springer. 1992.

Title of the Master: Mathematical Analysis and Applications
Semester: S1
Unit title: MTU1.1
Subject title: Continuous optimization
Credits: 05
Coefficients: 03

Teaching objectives: The purpose of this course is to present the main methods of continuous optimization and to apply them to concrete examples, through the computer implementation stage.

Recommended prior knowledge: Classic courses of the license (Differential calculus, Numerical analysis 1).

Content of the course:

- Introduction.

• Definition of optimization problems in R^n.

• Reminders of differential calculus, Fréchet differential, Hessian, implicit function theorem.

- Convexity.

• Convex sets and functions.

• Existence and/or uniqueness of the minimum of a function. Necessary first-order optimality conditions. Second-order necessary and/or sufficient conditions.

- Unconstrained minimization algorithms: Newton, Quasi-Newton, gradient, optimal step gradient, conjugate gradient, relaxation, probabilistic algorithms.

- **Problems with constraints:** Lagrangian, Lagrange multipliers. Kuhn-Tucker theorem. Dual primal methods (Uzawa, SQP, Lagrange, Newton). First and second order optimality conditions, with constraints. Internal and external penalization methods.

- Implementation of various algorithms application to well-chosen examples.

Evaluation method: Exam (60%), continuous control (40%).

Références :

- Auslender, Optimisation, méthodes numériques, Masson, 1976.
- J.P Ciarlet, Analyse Numérique matricielle et introduction à l’optimisation, Masson, 1982.
- J.C. Culioli, Introduction à l'optimisation, Ellipses, 1998.
- Ekeland, R. Temam, Analyse convexe et problèmes variationnels, Dunod, 1974.

Title of the Master: Mathematical Analysis and Applications
Semester: S1
Unit title: **MTU1.2**
Subject title: Scientific calculation
Credits: 04
Coefficients: 02

Teaching objectives: The aim of this course is to illustrate the use of scientific computing environments (such as Matlab or Scilab) for solving scientific problems, based on numerical and symbolic calculation and visualization.

Recommended prior knowledge: Classic courses of the license (Algorithms, Linear Algebra, Numerical Analysis).

Content of the course:

- Reminders of algorithms and programming (Matlab, Scilab, Octave, ...)
  - • Application to the resolution of non-linear equations
- Linear systems
  - • Reminders of linear algebra (properties of matrices, matrix norms, inversion, conditioning, decompositions, ...)
  - • Iterative methods, High-dimensional matrix, Sparse matrix
  - • General projection methods
  - • Pre-conditioning techniques
  - • Krylov's methods
  - • Parallel implementations (GPU)
- Approximation of functions and data
  - • Least squares problems
  - • Polynomial and spline approximation in one and two dimensions
- Fourier transforms

-Simulation of random variables and Monte-Carlo methods

Evaluation method: exam and data processing mini-project

Références :

Alfio Quarteroni et al., Calcul scientifique, Cours, exercices corrigés et illustrations en MATLAB et OCTAVE, Springer edition, 2010.

Title of the Master: Mathematical Analysis and Applications
Semester: S1
Unit title: TTU1.1
Subject title: Basic English
Credits: 02
Coefficients: 01

Teaching objectives: To master technical expression in English as well as communication using this language.

Recommended prior knowledge: Basic English

Content of the course:

- Teaching the specialized vocabulary of applied mathematics.
- Students learn how to use the basic language of mathematics to communicate effectively in the formal register of applied mathematics.
- Teaching the grammatical rules and structures of applied mathematics, including the use of empirical evidence, logical arguments, skepticism, questioning, criticism, reflecting, predicting, hypothesizing, etc.
- Exposing and introducing students to mathematical discourse through mathematical texts. This is likely to enhance their knowledge and understanding of mathematical terminology and register (definitions, specification, theorems, proofs, restatements, pointers, citations,…etc)

Evaluation method: exam

Title of the Master: Mathematical Analysis and Applications
Semester: S1
Unit title: TTU1.2
Subject title: Scientific communication
Credits: 01
Coefficients: 01

Teaching objectives: The aim of this course is to introduce students to scientific writing software (SWP, Latex). These software have become essential tools for the processing of mathematical texts.

Recommended prerequisites: Basic computer science and undergraduate mathematics.

Content of the course:

- Method of preparation of presentations, methods of presentation of presentations.
- Method of preparing for interviews.
- Method of writing articles, documents, etc.
- Preparation of presentations and standard projects.

Evaluation method: Control Continuous

Références :

- Leslie Lamport. LATEX: A Document Preparation System. Addison-Wesley, 1994.
- American Mathematical Society AMS-LATEX Version 1.2 User's guide.
- Introduction à Maple, Jean-Michel Ferrard, 2001.

Title of the Master: Mathematical Analysis and Applications
Semester: S2
Unit title: **FTU2.1.1**
Subject title: **Fourier analysis**
Credits: 06
Coefficients: 03

Teaching objectives: This course teaches the spaces of functions and distributions where the Fourier transformation is defined, as well as the important properties of this transformation.

Recommended prerequisites: Real License Level Analysis and S1 Distributions.

Content of the course:

- Space $S(R^n)$ of rapidly decreasing functions.
- Space $S'(R^n)$ of tempered distributions.
- Fourier transform on $L^1(R^n)$. Fourier transform on $S(R^n)$.
- Fourier transform on $S'(R^n)$. Properties of the Fourier transformation on $S'(R^n)$.
- Convolution theorem in $S'(R^n)$. Fourier transform on $E'(R^n)$. Apps.

Evaluation method: Exam (60%), continuous control (40%).

Références :

1. Bony J. M., Cours d’analyse. Théorie des distributions et analyse de Fourier. Ellipses, 2001.
2. Friedlander G., Joshi M., Introduction to the theory of distributions. Cambridge University. Press. 1998.
3. Hörmander L., Distribution theory and Fourier analysis. Springer, 2000.
4. Zuily C., Distributions et équations aux dérivées partielles, exercices corrigés. Hermann, 1986.
5. Zuily C., Eléments de distributions et équations aux dérivées partielles. Dunod, 2002.

Title of the Master: Mathematical Analysis and Applications
Semester: S2
Unit title: FTU2.1.2:
Subject title: Holomorphic and meromorphic functions
Credits: 04
Coefficients: 02
Teaching objectives: This course is an introduction to holomorphic and meromorphic functions; it gives the fundamental concepts and results.

Recommended prerequisites: Complex analysis of the License level.

Content of the course:
- Reminders
• Entire series.
• analytical functions

- Holomorphic functions.
• Definition of holomorphic functions.
• Analyticity of holomorphic functions.
• The great theorems on holomorphic functions.

- Singular points, meromorphic functions.
• Holomorphic functions in a crown and Laurent series.
• Singular points, meromorphic functions.
• The Riemann sphere.

- Curvilinear, primitive integrals.
• Integration along the paths.
• Homotopy of paths and integrals of holomorphic functions.
• Primitive problems.
• Index of a point in relation to a lace.

Evaluation method: Exam (60%), continuous control (40%).

Références :

- L. Ahlfors, Complex Analysis, Mc Graw-Hill, 1966.
- W. Rudin, Analyse réelle et complexe, Masson, 1975.
- Hille, Analytic function theory, Vols. 1 and 2, Chelsea, 1962.
- R. Nevanlinna, V. Paatero, Introduction to Complex Analysis, Addison-Wesley, 1964.
- P. Tauvel, Analyse complexe, Dunod,, 1999, Exercices corrigés.
- J. Kuntzmann, Variable complexe. Hermann, Paris, 1967.

Title of the Master: Mathematical Analysis and Applications
Semester: S2
Unit title: FTU2.2.1
Subject title: computer vision
Credits: 04
Coefficients: 02

Teaching objectives: This course is an introduction to computer vision. It presents an overview of vision problems expressed in a mathematical framework, as well as resolution techniques.

Recommended prior knowledge: Real Analysis, Linear Algebra, Optimization.

Content of the course:

- Imaging

• Cameras and notions of optics.

- Interpretation of intensities

• Color and illumination.

- Detection and matching of characteristic points

• Edge and corner detection.

• Local descriptors.

• Hough transformation.

• Data adjustment and RANSAC algorithm.

- Motion estimation.

- Multiple image geometry and three-dimensional reconstruction.

- Detection and recognition of objects.

Evaluation method: Exam (60%), continuous control (40%).

Références :

- Richard Sealskin, Computer Vision: Algorithms and Applications, Texts in Computer Science, 2011.
- David Forsyth, Jean Ponce, Computer Vision: A Modern Approach, Prentice Hall Professional Technical Reference, 2002.
- Klette Reinhard, Concise Computer Vision: An Introduction into Theory and Algorithms, Springer Publishing Company, 2014.

Title of the Master: Mathematical Analysis and Applications
Semester: S2
Unit title: **FTU2.2.2**
Subject title: Differential inclusions
Credits: 04
Coefficients: 02
Teaching objectives: This course is an introduction to differential inclusions. We will focus on dynamic systems under constraint. Other applications will be studied, namely: Dependence of ODE solutions on initial conditions, controllability etc.....

Recommended prior knowledge: Differential equations S1 course and license.

Undergraduate topology course.

Content of the course:
- Introduction to multivocal analysis.

• On the topology of hyper-spaces: Vitoris topology, Hausdorff distance.

• Multivocation functions (General definitions: Domain, Graph of a multivocation and Inverse multivocation).

• Continuity and measurability of many-sided functions.

• On selections. Michael's theorem.

• Differentiability of a multivocal function.

• On the fixed point theory of multivocal functions.

- Differential inclusions.

• Generalities (Notion of solution, Cauchy problem)

• On the existence theory of solutions in the finite dimension.

• On the theory of existence of solutions in the infinite dimension.

- Constrained differential inclusions.

• Tangent cone of Severi-Bouligand, Clark and the proximal cone.

• Differential inclusions subject to constraints (viability).

• Applications: Fixed point, periodic solution of a differential equation.

Evaluation method: Exam (60%), continuous control (40%).

Références :

- Aubin J.P, Frankowska H. Set-valued analysis. Boston: Birkhauser Inc MA. 1990.
- Carja O, Necula M, Vrabie II. Viability, invariance and applications. Amsterdam: Elsevier Science B V. 2007.

Title of the Master: Mathematical Analysis and Applications
Semester: S2
Unit title: MTU2.1:
Subject title: Convex optimization
Credits: 05
Coefficients: 03

Teaching objectives: The main objective of this course is to learn to recognize, manipulate and solve a relatively large class of emerging convex problems in fields such as, for example, signal processing. The course begins with a few reminders of convex analysis and duality theory. A second part presents the first-order and interior-point algorithms, as well as the bounds on their complexity. The course ends with a presentation of applications.

Recommended prerequisites: First semester course.

Content of the course:

- Introduction.
- Modelization.
  - Sets, functions and convex programs.
  - Convex analysis reminders.
  - Duality.
- Algorithms.
  - Interior point methods.
  - Constraints, barriers, self-concordance and complexity.
  - First-order methods, speedup and optimal complexity.
- Applications: Image processing.

Evaluation method: Exam (60%), continuous control (40%).

Références :

- Y. Nesterov, Introductory Lectures on Convex Optimization, Springer.
- S. Boyd and L. Vandenberghe, Convex Optimization, Cambridge University Press.
- Nemirovski and A. Ben-Tal, Lectures on Modern Convex Optimization, SIAM.

Title of the Master: Mathematical Analysis and Applications
Semester: S2
Unit title: MTU2.2:
Subject title: Fractional calculS
Credits: 04
Coefficients: 02
Teaching objectives:

The objective of this course is to recall some elementary notions of fractional calculus. These tools have as application (among others) the existence and non-existence of solutions for certain types of evolution equations.

Recommended prior knowledge: Differential calculus, ODE theory.

Content of the course:

- Special functions.
• Definitions of Gamma and Beta functions.
• Properties of Gamma and Beta functions.
• Definition of the Mittag-Lefler function.
- Derivatives and Fractional Integrals.
• Integrals of arbitrary order.
• Derivative of arbitrary order.
• Fractional derivative in the sense of Grunwald-letnikov.
• Fractional derivative in the sense of Riemman-Liouville.
• Fractional derivative in the sense of Caputo.
• Left and right fractional derivative.
- Operations on fractional derivatives.
• Composition with integer derivatives.
• Composition with fractional derivatives.
• Leibniz's rule for fractional derivatives.

Evaluation method: Exam (60%), continuous control (40%).

Références :

1. Nicolas Bacaër : Histoires de mathématiques et de populations, Cassini, Paris, 2009,
2. Nicolas Bacaër, Histoires de mathématiques et de populations, Éditions Cassini, coll. « Le sel et le fer », 2008, « Lotka et la « biologie physique » / Volterra et la « théorie mathématique de la lutte pour la vie ».

Title of the Master: Mathematical Analysis and Applications
Semester: S2
Unit title: TTU2.1
Subject title: Scientific English
Credits: 02
Coefficients: 01

Teaching objectives: Master the techniques of expression in English as well as communication.

Recommended prior knowledge: Basic English

Content of the course:

- Techniques of written communication.

- Presentation of methods for writing different documents.
• Research article.
• Bibliography.
• Book or chapter in a book.
• Internal research report.
• Minutes of meeting.
• A recruitment request.

- Technique of oral communication.
This part must be done in the form of practical exercises where the student must communicate orally in the following (simulated) situations:
• Present a presentation on a given assignment.
• Present yourself to a group of people with a view to recruitment.
• Simulate a work meeting, etc…..

Evaluation method: Final Exam

Title of the Master: Mathematical Analysis and Applications
Semester: S2
Unit title: **TTU2.2**
Subject title: Corruption and Work Ethics
Credits: 01
Coefficients: 01

Teaching objectives:

Inform and sensitize students to the risk of corruption and encourage them to contribute to the fight against corruption.

Recommended prior knowledge:

Content of the course:

- Corruption concept.
- Types of corruption.
- Manifestations of administrative and financial corruption.

- The reasons for administrative and financial corruption.
1. Causes of corruption from the point of view of theoreticians.
2. General causes of corruption.
- The effects of administrative and financial corruption.
- The fight against corruption by local and international bodies and organisations.
- Methods of treatment and ways to combat the phenomenon of.
- Models of the experience of certain countries in the fight against corruption.

Evaluation method: Final exam.

References :

Documentation provided by the MESRS

Title of the Master: Mathematical Analysis and Applications
Semester: S3
Unit title: **FTU3.1**
Subject title: Spectral theory of operators and semi groups
Credits: 06
Coefficients: 03

Teaching objectives: This course first introduces the spectral analysis of unbounded operators, then the semi-groups of operators and ends with an application to the linear Cauchy problem.

Recommended prior knowledge: Functional analysis of Semester 1.

Content of the course:

- Reminder on Hilbert Spaces and Bounded Operators and Hilbert Basis Lax-Milgram Theorem.

- Addition. Spectrum of Self-Adjoint Bounded Operators Spectrum of Compact Operators.

- Functional Calculation of Self-Adjoint Bounded Operators Unbounded Operators: Closed operators. Closeable Operators. Assistant Operators. Self-Adjoint Operators. Spectrum. Compact Resolvent Operators. Spectral theorem.

- Notions on semi-groups of operators: Definition. Infinitesimal generator. Hille-Yosida theorem.

- Linear Cauchy problem.

Evaluation method: Exam (60%), continuous control (40%).

Références :

- Rudin W., Analyse réelle et complexe. Masson, 1980.
- Yosida K., Functional analysis. Springer, 1980.
- Schwartz L., Topolgie et Analyse Fonctionnelle. Hermann.

Title of the Master: Mathematical Analysis and Applications
Semester: S3
Unit title: FTU3.2
Subject title: Fractional Differential Equations
Credits: 06
Coefficients: 03
Teaching objectives:
This subject presents a dynamical systems theory approach to understanding the qualitative properties of solutions of evolution equations in a fractional framework, such as fractional reaction-diffusion systems and the modeling of some miscellaneous physical systems.

Recommended prior knowledge: ODE theory and PDE theory.

Content of the course:

- Theorems of existence and uniqueness.
• Linear fractional differential equations
• General fractional differential equations
• Existence and uniqueness theorems
• Dependence of solutions on initial conditions.
- Laplace Transform for Fractional Differential Equations
• Standard fractional differential equations.
• Sequential fractional differential equations.
- Green's function for fractional differential equations
• General
• Application to some fractional differential equations.
- Some special EDF solving methods.
• Mellin transform method.
• Method of orthogonal polynomials.
• Symbolic calculation method.

Evaluation method: Exam (60%), continuous control (40%).

Références :

- Nicolas Bacaër : Histoires de mathématiques et de populations, Cassini, Paris, 2009,

- Vito Volterra et Marcel Brelot, Théorie mathématique de la lutte pour la vie, Paris, Éditions Gauthier-Villars, 1931 (réimpr. facsimile 1990 aux éd. J. Gabay), 216 p.
- Nicolas Bacaër, Histoires de mathématiques et de populations, Éditions Cassini, coll. « Le sel et le fer », 2008, « Lotka et la « biologie physique » / Volterra et la « théorie mathématique de la lutte pour la vie ».
- R. Leigh (1968) The ecological role of Volterra's equations, in Some Mathematical Problems in Biology - a modern discussion using Hudson's Bay Company data on lynx and hares in Canada from 1847 to 1903.
- Understanding Nonlinear Dynamics. Daniel Kaplan et Leon Glass.

Title of the Master: Mathematical Analysis and Applications
Semester: S3
Unit title: **FTU3.3**
Subject title: Advanced models for image processing
Credits: 06
Coefficients: 03
Teaching objectives: This course aims to present elaborate and recent mathematical models used in image processing.

Recommended prior knowledge: M1 courses, in particular those of image processing and optimization.

Content of the course:

- Some mathematical tools for the image
• Inverse Problems and Modeling
  ✓ Example of a restoration and reconstruction problem
  ✓ Ill-posed inverse problem and Hadamard conditions - Relation with eigenvalues, conditioning, Regularization
• Optimization in Banach spaces.
• Variational formulation of partial differential equations.
• Non-smooth convex analysis.
- Some image restoration models.
• Partial differential equations: Isotropic filtering by the heat equation, Equation of Malik and Perona, Motion by mean curvature.
• Tychonov regularization: BV space, Rudin-Osher-Fatemi model, Chambolle projection algorithm.
- Image segmentation
• Active Contours: Active Contours, Level Lines, Balloon Model.
• Mumford-Shah model.
- Image registration: Rigid and non-rigid case, floatoptic.
- Fundamental problems in three-dimensional reconstruction.
- Use and implementation of algorithms in Matlab.

Evaluation method: Exam (60%), continuous control (40%).

Références :

- R.C. Gonzales, R.E. Woods, Digital image processing, Prentice Hall 2002.
- Maitre et al., Traitement numérique des images, Cours ENST, 2008.
- J. Weickert, Anisotropic Diffusion in Image Processing
  ECMI Series, Teubner-Verlag,1998.
- Jean-Michel Morel, Sergio Solimini , Variational methods in image segmentation, Birkhäuser, 1995.
- Tony Chan, Jianhong Shen, Image Processing And Analysis: Variational, Pde, Wavelet, And Stochastic Methods, SIAM, 2005.

Title of the Master: Mathematical Analysis and Applications
Semester: S3
Unit title: MTU3.1
Subject title: Differential inclusion and optimal control
Credits: 06
Coefficients: 03
Teaching objectives: This course focuses on the qualitative study of differential systems subject to constraints. We will investigate the theory of controllability as well as some models in economics.

Recommended prior knowledge: Topology, functional analysis, ordinary differential equations, S1 and S2 courses.

Content of the course:

- On the relaxation of differential inclusions
- Properties of the set of solutions of a differential inclusion governed by a monotone operator
- Differential inclusion and optimal control.
• Theory of existence
• Relaxation and control systems.
• Variational stability and optimal control.
- Mathematics and economics.

Evaluation method: Exam (60%), continuous control (40%).

Références :

- Lakshmikantham, V., Leela, S.: Nonlinear differential equations in abstract spaces. Pergamon Press, Oxford (1981).
- Roubicek, T.: Nonlinear partial differential equations with applications, Birkhauser, Basel (2005).
- Papageorgiou N.: Handbook of Multivalued Analysis, Volume II Applications, Kluwer, Dordrecht (2000).

Title of the Master: Mathematical Analysis and Applications
Semester: S3
Unit title: MTU3.2
Subject title: Numerical analysis for differential equations
Credits: 03
Coefficients: 02
Teaching objectives: To introduce students to numerical methods for differential equations (ODE and PDE) and for integro-differential equations, in particular the method of differences. The method of approximation using Spline polynomials and orthogonal polynomials has become popular. It is intended, in particular, for ordinary differential equations and integral equations.

Recommended prerequisites: Linear Algebra, E. D. O and E. D. P.

Content of the course:

- Finite difference method for ODE and for ED.
• Principles of the finite difference method
• Simple 1D example with mixed conditions, Dirichlet, Neumann
• Higher Order Schema, Explicit Schema and Implicit Schema
• Discretization of the 1D heat equation
• Discretization of the stationary 2D Laplace equation
- Spline polynomials
• Polynomial Spline Spaces: Definitions and Notations.
• Basic B-Splines.
• Cubic splines and their applications
• Applications to the numerical resolution of differential and integro-differential equations.
- Approximation by orthogonal polynomials.
• Legendre, Tchebychev, Hermite and Jacobi polynomials.
• Better approximation by orthogonal polynomials.
• Quadrature formulas based on orthogonal polynomials.

• Solving differential and integral equations using collocation methods based on orthogonal polynomials.
- Numerical methods associated with differential equations with initial conditions and boundary conditions.
• Transformation of differential equations to integral equations.
• Methods based on Taylor expansions.
• Explicit and implicit Runge-Kutta methods.
• Collocation methods.

Evaluation method: Exam (60%), continuous control (40%).

Références :

- Papageorgiou N.: Handbook of Multivalued Analysis, Volume II Applications, Kluwer, Dordrecht (2000).
- K. E. Atkinson, W. Han: Theoretical numerical analysis, 2nd edition, Springer Verlag, Berlin, 2005.
- R. L. Burden, J. D. Faires: Numerical Analysis, 9th Edition, PWS publishing company, Boston, 2011.
- Canuto, M.Y. Hussaini, A. Quarteroni, T.A. Zang, Spectral methods, fundamentals in single domains, Springer-Verlag, Berlin, 2006.
- P. G. Ciarlet: Introduction à l'analyse numérique matricielle et à l'optimisation, Dunod, Paris, 1998.
- J. Shen, T. Tang: Spectral and High-Order Methods with Applications, Science Press, Beijing, 2006.
- L. L. Schumaker, Spline Functions : Basic Theory, third edition, Cambridge University Press, 2007.
- Suli and D. F. Mayers : An Introduction to Numerical Analysis , Cambridge University Press, 2003.

Title of the Master: Mathematical Analysis and Applications
Semester: S3
Unit title: TTU3.1
Subject title: Scientific Calculus for Differential Equations
Credits: 02
Coefficients: 01

Teaching objectives: Enable students to implement numerical methods for solving differential equations.

Recommended prerequisites: Undergraduate courses in numerical analysis and differential equations.

Content of the course:
- Orthogonal polynomials in approximation theory
• Approximation of functions by generalized Fourier series: Polynomials of Chebyshev, of Legendre
• Interpolation and integration of Gauss, Chebyshev, Legendre
• Gaussian integration over unbounded intervals
• Implementation of Gaussian quadratures
• Approximation of derivatives: Classical, compact, and pseudo-spectral finite difference methods
- Numerical resolution of ordinary differential equations
• One-step numerical methods
• Difference equations
• Multi-step methods: Adams, BDF
• Preacher-corrector methods
• Runge-Kutta methods
• Systems of ordinary differential equations
- Boundary problems in dimension one
• Approximation by finite differences: stability, convergence
- Parabolic and hyperbolic transient problems
• Heat equation: approximation by finite differences

Emphasis should be placed on the study of several examples of differential equations and the implementation and study (stability, consistency, convergence

Evaluation method: continuous control

Références :

- Alfio Quarteroni et al., Calcul scientifique, Cours, exercices corrigés et illustrations en MATLAB et OCTAVE, Springer edition, 2010.

Title of the Master: Mathematical Analysis and Applications
Semester: S3
Unit title: TTU 3.2 :
Subject title: Seminar
Credits: 01
Coefficients: 01

Teaching objectives: Allow students to participate in a regular activity of scientific presentation of articles or research topics.
Prior knowledge recommended

Content of the course: Flexible (depending on the presentations).

Evaluation method: continuous control

V- Agreements or conventions

NO

(If yes, send the agreements and/or conventions in the training paper file)