Semester 5 Modules : Specialization Data Science & computer Vision (Vision par Ordinateur et Science des données - DS-CV-)

Code	Title	type	Coeffi-cients	ECTS	Total work-load	Contact hours	Private study
AI.5.12	Machine and Deep Learning	Compulsory	2	2	50	30	20
CV.5.1	Restoration and digital Considerations	Compulsory	2	2	50	30	20
CV.5.2	Shape recognition and geometric invariants	Compulsory	2	2	50	30	20
CV.5.3	3D representation: Curves, Shapes and Sur-faces	Optional	2	2	50	30	20
CV.5.4	Discrete Representation of 3D Objects	Optional	2	2	50	30	20
CV.5.5	Compression techniques for computer vision applications	Optional	2	2	50	30	20
CV.5.6	Mathematical Morphology and medical appli-cations	Compulsory	2	2	50	30	20
CV.5.7	Multispectral image processing	Compulsory	2	2	50	30	20
CV.5.8	Multidimensional signal processing	Optional	2	2	50	30	20
CV.5.9	Computer vision	Optional	2	2	50	30	20
ISA.5.1	Big Data	Compulsory	2	2	50	30	20
AI.5. 13	Machine and Deep Learning Workshops	Compulsory	1	1	25	15	10
AI.5.14	Speech recognition & Chatbots application	Compulsory	1	1	25	15	10
AI.5.15	Optimization and Reinforcement Learning	Compulsory	1	1	25	15	10
AI.5.16	Introduction to Natural Language Processing	Optional	1	1	25	15	10
CV.5.11	Medical Imaging Workshops	Compulsory	1	1	25	15	10
DOS.5.2	Blockchain	Optional	1	1	25	15	10
DOS.5.3	IoT	Optional	1	1	25	15	10
DOS.5.8	Introduction to cloud computing	Optional	1	1	25	15	10
SE.5.3	Mobile Development	Optional	1	1	25	15	10
	Complementary Module 1		2	2	50	30	20
	Complementary Module 2		2	2	50	30	20
	Complementary Module 3		2	2	50	30	20
	Complementary Module 4		1	1	25	15	10
	Complementary Module 5		1	1	25	15	10
	Complementary Module 6		1	1	25	15	10

AI.5.12 Machine and Deep Learning

Module designation	AI.5.12 Machine and Deep Learning
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Faouzi Ghorbel
Language	French
Relation to curriculum	Compulsory
Teaching methods	lesson, lab works.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	• IMA.2.1 Image Introduction • Basic probability and statistics (conditional and joint distribution, independence, Bayes rule, random variables, expectation, mean, median, mode, central limit theorem) • Basic linear algebra (matrix/vector multiplications, systems of linear equations, SVD) • Multivariate calculus (derivative w.r.t. vector and matrix variables) • Basic Programming Skills (Matlab and Python) Competencies: C1, C2, C3, C4
Module objectives/intended learning outcomes	In this course, fundamental principles and methods of machine learning will be introduced, analyzed and practically implemented. An overview of existing processings and methods, at teaching how to design and train a deep neural network for a given task, and at providing the theoretical basis to go beyond the topics directly seen in the course.
Content	Chapter I. Basic regression and classification concepts and methods: 1. Linear models, 2. overfitting, 3. linear regression, 4. Ridge regression, 5. logistic regression, 6. k-NN, 7. SVMs and kernel methods Chapter II. Fundamental concepts 1. cost-functions and optimization, 2. cross-validation and bias-variance trade-off, 3. curse of dimensionality. Chapter III. Neural Networks 1. Representation power, 2. Backpropagation, 3. activation functions, CNN, 4. regularization, 5. data augmentation, 6. dropout Chapter IV. Unsupervised learning: 1. k-means clustering, 2. Gaussian mixture models and the EM algorithm. 3. Basics of self-supervised learning Chapter V. Dimensionality reduction: 1. PCA and matrix factorization, 2. word embeddings Chapter VI. Advanced methods: 1. Adversarial learning,

	2. Generative adversarial networks Chapter VII. Deep Learning 1. What is deep learning 2. introduction to tensors. 3. Generalized networks, 4. autograd, batch processing, 5. convolutional networks. 6. Deep models for Computer Vision 7. Analysis of deep models.
Examination forms	100% Final exam
Study and examination requirements	10/20
Reading list	Bishop, C. M., & Nasrabadi, N. M. (2006). Pattern Recognition and Machine Learning. New York: Springer. Murphy, K. P. (2012). Machine Learning: A Probabilistic Perspective. MIT Press. Shalev-Shwartz, S., & Ben-David, S. (2014). Understanding Machine Learning: From Theory to Algorithms. Cambridge University Press. Nielsen, M. A. (2015). Neural Networks and Deep Learning. San Francisco, CA, USA: Determination Press. Hastie, T., Tibshirani, R., Friedman, J. H., et al. (2009). The Elements of Statistical Learning: Data Mining, Inference, and Prediction. New York: Springer.

CV.5.1 Restoration and Digital Considerations

Module designation	CV.5.1 Restoration and Digital Considerations
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Slim MHIRI
Language	French
Relation to curriculum	Compulsory
Teaching methods	lesson, lab works.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	• IMA.2.1 Image Introduction • Basic probability and statistics (conditional and joint distribution, independence, Bayes rule, random variables, expectation, mean, median, mode, central limit theorem) • Basic linear algebra (matrix/vector multiplications, systems of linear equations, SVD) • Multivariate calculus (derivative w.r.t. vector and matrix variables) • Basic Programming Skills (Matlab and Python)
Module objectives/intended learning outcomes	This course aims to: - present, within the unifying framework of Bayesian estimation, methods for solving inverse problems. - understand particularly image restoration, signal deconvolution and image reconstruction. Competencies: C1, C9

Content	Chapter 1. Inverse problems examples: Deconvolution, Image restoration, Image reconstruction, Fourier synthesis, ... Chapter 2. Classification of inversion methods: Analytical, Parametric and Non Parametric algebraic methods Chapter 3. Regularization theory Chapter 4. Bayesian inference for invese problems Chapter 5. Full Bayesian with hyperparameter estimation Chapter 6. Two main steps in Bayesian approach: Prior modeling and Bayesian computation Chapter 7. Priors which enforce sparsity Chapter 8. Heavy tailed: Double Exponential, Generalized Gaussian, ... Chapter 9. Mixture models: Mixture of Gaussians, Student-t, ... ◮ Gauss-Markov-Potts Chapter 10. Computational tools: MCMC and Variational Bayesian Approximation Chapter 11. Some results and applications : X ray Computed Tomography, Microwave and Ultrasound imaging, Sattelite Image separation, Hyperspectral image processing, Spectrometry, CMB, ...
Examination forms	100% Final exam
Study and examination requirements	10/20
Reading list	Gonzalez, R. C. (2009). Digital Image Processing. Pearson Education India.

CV.5.2 Shape Recognition and Geometric Invariants

Module designation	CV.5.2 Shape Recognition and Geometric Invariants
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Faouzi Ghorbel
Language	French
Relation to curriculum	Compulsory
Teaching methods	lesson, lab works
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	IMA.2.1 Image Introduction • Basic probability and statistics (conditional and joint distribution, independence, Bayes rule, random variables, expectation, mean, median, mode, central limit theorem) • Basic linear algebra (matrix/vector multiplications, systems of linear equations, SVD) • Multivariate calculus (derivative w.r.t. vector and matrix variables) • Basic Programming Skills (Matlab and Python)
Module objectives/intended learning outcomes	This course aims to Introduce the main methods of image analysis and pattern recognition. Competencies: C1, C9
Content	Chapter I. Shape representation and description Chapter II. Shape recognition Chapter III. Invariant Theory Chapter IV. Practical works on computers
Examination forms	100% Final exam
Study and examination requirements	10/20
Reading list	Kunt, M. (2000). Reconnaissance des formes et analyse de scènes. PPUR presses polytechniques. Sonka, M., Hlavac, V., & Boyle, R. (2014). Image processing, analysis, and machine vision. Cengage Learning.

CV.5.3 3D representation: Curves, Shapes and Surfaces

Module designation	CV.5.3 3D representation: Curves, Shapes and Surfaces
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Mehdi Hajji
Language	French
Relation to curriculum	Compulsory
Teaching methods	lesson, lab works, projects.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	IMA.2.1 Image Introduction
Module objectives/intended learning outcomes	This course aims to: - make a description of 3D curves and 3D surfaces. - explain the different approaches to representing 3D shapes. - make an isotropic representation of 3D object surfaces Competencies: C1, C9
Content	Chapter I - Introduction a. Introduction b. Difficulties and limitations c. Problem d. Desirable properties e. Goals Chapter II- Curves in 3D a. Parametric curves: general information and metric study b. Local shape of plane curves c. Local shape of left curves d. Exercises Chapter III- 3D surfaces a. Introduction b. Parametric surfaces c. Local shape of a surface d. Exercises Chapter IV- Different approaches to the representation of 3D shapes a. Introduction b. Continuous representations: Implicit algebraic surfaces c. Discrete representations: Triangulations Chapter V- Isotropic representation of 3D object surfaces a. Introduction b. Problem of isotropy c. Pseudo reparameterization of IR3 surface
Examination forms	35% Continues evaluation + 65% Written exam
Study and examination requirements	10/20
Reading list	Farin, G. (2014). Curves and surfaces for computer-aided geometric design: A practical guide. Elsevier.

CV.5.4 Discrete Representation of 3D Objects

Module designation	CV.5.4 Discrete Representation of 3D Objects
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Majdi Jribi
Language	French
Relation to curriculum	Optional
Teaching methods	lesson, projects.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	IMA.2.1 Image Introduction
Module objectives/intended learning outcomes	This course aims to: - Understand the importance of 3D data in the field of shape recognition. Students are able to: - Master 3D mesh simplification methods. - Master 3D registration methods. - Master of the methods of 3D objects construction from a discrete cloud of points. Competencies: C1, C9
Content	Chapter I: From 2D to 3D I.1. Comprehension of 2D images and limitations I.2. 3D shape and discrete representation Chapter II. 3D object construction II.1. 3D modality acquisition II.2. Voronoi diagram II.3. Method 1 of construction: Delaunay triangulation II.4. Method 2 of construction: Crust triangulation Chapter III. 3D mesh simplification III.1. Basic concepts of 3D mesh III.2. Definition of the simplification notion III.3. The vertex clustering method III.4. The vertex removal method III.5. The edge collapse method III.6. The half edge collapse method Chapter IV. 3D object registration IV.1. Definition of the registration notion IV.2. Steps of registration IV.3. The ICP algorithm
Examination forms	35% Continues evaluation + 65% Written exam
Study and examination requirements	10/20
Reading list	Montagnat, J., & Delingette, H. (2001). A review of deformable surfaces: Topology, geometry and deformation. Image and Vision Computing, 19(14), 1023-1040.

	Nikolaidis, N., & Pitas, I. (2000). 3D image processing algorithms. J. Wiley & Sons.

CV.5.5 Compression Techniques for Computer Vision Applications

Module designation	CV.5.5 Compression Techniques for Computer Vision Applications
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Dorsaf Sebai
Language	French
Relation to curriculum	Compulsory
Teaching methods	lesson, lab works, projects.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	IMA.2.1 Image Introduction
Module objectives/intended learning outcomes	This course aims to: - Identify the role of images in the data science and computer vision fields. - Identify the compression challenges in IoT context. - Distinguish the basic concepts and different types of compression. Students are able to: - Get familiarized with different compression techniques applied to different types of images in 2D and 3D contexts. - Understand the main functional blocks of MPEG compression standards for still images and videos. - Discover the new compression trends based on scalability and deep learning. Competencies: C1, C9
Content	Chapter 1. Basic concepts of visual data compression Chapter 2. Compression for 3D computer vision Chapter 3. Sparse representations Chapter 4. Scalable compression Chapter 5. Deep learning based compression Chapter 6. Compression in IoT context
Examination forms	100% Final exam
Study and examination requirements	10/20
Reading list	Yesilyurt, A. B. (2019). End-to-end learned image compression with conditional latent space modeling for entropy coding [Doctoral thesis]. Mosbah, S., Sebai, D., & Ghorbel, F. (2019). Analysis of SHVC Coding Tree Unit Partitioning for Depth Maps SNR Scalability. In 8th International Workshop on Representation, Analysis and Recognition of Shape and Motion from Imaging Data (RFMI). Rana, K., & Thakur, S. (2017). Data Compression Algorithm for Computer Vision Applications: A Survey. In International Conference on Computing, Communication and Automation (ICCCA). Ebrahimi, T., & Kunt, M. (1998). Visual data compression for multimedia applications. Proceedings of the IEEE, 86(6), 1109-1125.

CV.5.6 Mathematical Morphology and medical applications

Module designation	CV.5.6 Mathematical Morphology and medical applications
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Dorra DHOUIB
Language	French
Relation to curriculum	Compulsory
Teaching methods	lesson, projects.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	IMA.2.1 Image Introduction
Module objectives/intended learning outcomes	This course aims to: - Understand the importance of mathematical morphology techniques in the field of medical images. Students are able to: - Master mathematical morphology techniques - Applicate mathematical morphology techniques in image analysis and processing - Applicate mathematical morphology techniques for medical images Competencies: C1, C9
Content	Chapter I: Introduction 1. The different medical imaging methods 2. Fundamental concepts of the image 3. Pretreatment Chapter II. Basic operators 1. Concept of treillis 2. Concept of sets 3. Properties of operations on sets 4. Minkowski operations 5. Binary morphological transformations 6. Morphological transformations on images in gray levels 7. Operators by combination 8. Operators by difference 9. Neighborhood transformations Chapter III. Discreet representation and advanced operators 1. Geodesia 2. Discreet representation 3. Granulometry 4. Alternate sequential filter 5. Ultimate erodes 6. Geodesic measures Chapter IV. Watershed and skeletonization 1. Watershed 2. Skeletonization
Examination forms	35% Continues evaluation + 65% Written exam
Study and examination requirements	10/20
Reading list	Maitre, H. (2003). Le traitement des images, coll. traitement du signal et de l'image (traité IC2). Lavoisier/Hermes Science Publications.

	Najman, L., & Talbot, H. (Eds.). (2013). Mathematical morphology: From theory to applications. John Wiley & Sons. Serra, J., & Soille, P. (Eds.). (2012). Mathematical morphology and its applications to image processing. Springer Science & Business Media.

CV.5.7 Multispectral image Processing

Module designation	CV.5.7 Multispectral Image Processing
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Dorra Dhouib
Language	French
Relation to curriculum	Compulsory
Teaching methods	lesson, lab works
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	IMA.2.1 Image Introduction • Basic probability and statistics (conditional and joint distribution, independence, Bayes rule, random variables, expectation, mean, median, mode, central limit theorem) • Basic linear algebra (matrix/vector multiplications, systems of linear equations, SVD) • Multivariate calculus (derivative w.r.t. vector and matrix variables) • Basic Programming Skills (Matlab and Python) Competencies: C1, C9
Module objectives/intended learning outcomes	This course aims to: - Detail optical remote sensing from satellites and airborne platforms. - Present different systems Students are able to: - acquire skills in image processing and machine/deep learning to extract end-products, such as land cover or risk maps, from the images.
Content	Chapter I. Basic concepts of remote sensing and digital imaging Chapter II. Platforms and sensors Chapter III. Information extraction, filtering, visual information Chapter IV. Image classification, with machine and deep learning Chapter V. Project: study a real (geospatial or other) problematic u cessing techniques.
Examination forms	100% Final exam
Study and examination requirements	10/20
Reading list	Caloz, R., & Collet, C. (2001). Précis de télédétection - Volume 3: Traitements numériques d'images de télédétection. PUQ. Camps-Valls, G., Tuia, D., Gómez-Chova, L., et al. (2011). Remote sensing image processing. Synthesis Lectures on Image, Video, and Multimedia Processing, 5(1), 1-192.

CV.5.8 Multidimensional Signal Processing

Module designation	CV.5.8 Multidimentional Signal Processing
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Slim Mhiri
Language	French
Relation to curriculum	optional
Teaching methods	The course consists of lectures accompanied by practical work to consolidate the understanding of the concepts
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	MAT.1.2 Engineering Mathematic
Module objectives/intended learning outcomes	This course is concerned with understanding signals of more than one variable and with systems for processing them. The most common examples of these signals include images, video, 3D… Competencies: C1, C9
Content	1. Multi-D Discrete-Time(Space) Signals and Systems 1.1 Representation of Multi-D Signals, Special 2-D Sequences 1.2 Multi-D Linear Shift-Invariant Systems, Discrete Convolution 1.3 Separable Systems 1.4 Implementation and Computational Cost I.5 Fourier Representation of Multi-D Discrete-Time Signals and Systems 0. Multi-D Sampling 2.1 The Sampling Theorem, Reconstruction 2.2 Rectangular Sampling 2.3 General Periodic Multi-D Sampling 2.4 2-D Hexagonal Sampling 2.5 Sampling Density, The Nyquist Density 2.6 Processing Signals Sampled on Arbitrary Lattices 0. Multi-D Discrete Fourier Transform (DFT) 3.1 Computable Transform for Multi-D Finite-Length Signals 3.2 Properties: Periodicity, Discrete Fourier Series 3.3 Rectangular Discrete Fourier Transform 3.4 Circular Convolution 3.5 Implementation: Direct, Row-Column Decomposition 3.6 Multi-D Vector-Radix Fast Fourier Transform 3.7 Computational Complexity and Storage Issues 3.8 General DFT for Signals Sampled on Arbitrary Lattices 3.9 Discrete Cosine Transform (DCT) and relation to DFT 0. Multi-D Finite Impulse Response (FIR) Digital Filters 4.1 Direct Implementation, DFT-based implementation, Block Processing 4.2 Window-based Designs 4.3 Optimal Least-Squares Designs 4.4 Optimal Constrained Designs 4.5 Fast Design and Realization Using Transformations

	0. Multi-D Infinite Impulse Response (IIR) Digital Filters 5.1 Two-D Difference Equations, Recursive Computability 5.2 Z-Transform: Definition, Region of Convergence, Properties 5.3 System Functions, Stability Analysis 5.4 Implementation: Recursive, Iterative 0. Processing of Propagating Space-Time Signals 6.1 Space-Time Signals, Plane Waves 6.2 Space-Time Filtering 6.3 Array Processing, Beamforming 6.4 Weighted Delay and Sum Beamformer 6.5 Seismic Migration, Geophysical Processing 0. Multi-D Signal Restoration and Reconstruction 7.1 Reconstruction from Projections, Back-Projection Algorithm 7.2 Reconstruction from Phase or Magnitude
Examination forms	100% Final exam
Study and examination requirements	10/20
Reading list	Dudgeon, D. E., & Mersereau, R. M. (1984). Multidimensional digital signal processing. Prentice Hall. Gonzales, R. C., & Woods, R. E. (1992). Digital image processing. Addison & Wesley. Jain, A. K. (1989). Fundamentals of digital image processing. Prentice Hall. Russ, J. C. (1992). The image processing handbook. CRC.

CV.5.9 Computer Vision

Module designation	CV.5.9 Computer Vision
Semester(s) in whichthemodu-leistaught	S5
Person responsible for themod-ule (coordinator)	Slim MHIRI
Language	French
Relation tocurriculum	optional
Teaching methods	The course consists of lectures accompanied by practical work to consolidate the understanding of theconcepts
Workload (incl. contacthours, self-studyhours)	Total workload:50h Contact hours :30h Private study:20h
Creditpoints	2 ECTS
Required and recommended prerequisites for joining the module	Geometry, image processing
Module objectives/intended learning outcomes	Master the fundamental tools of computer vision; design and im-plement solutions to different problems related to three-dimensional reconstruction; make a simple application. Competencies: C1, C9
Content	1. Introduction 2. Image formation Reminders; Landmarks; Relevant phenomena: geometric, op-tical, digital; Camera parameters: extrinsic, intrinsic. 3. Projective geometry Projective plane: homogeneous representation, line, points, intersection of 2 lines, ideal point, line at infinity, duality, con-ics; projective transformations: projectivity, transformations of lines and conics, hierarchy of transformations; apps 4. Calibration Parameter estimation: with model: without and with radial de-formation; Tsai's method, without model 5. Stereovision – spatial shifts Basic principles; matching; modelingoftherelationship-betweenextrinsicparametersandepipolargeometry: essential and fundamental matrices; peripolar geometry; image rectifi-cation: algorithm, reverse rectification, polar approach, projec-tive approach; constraints of a stereovision system 6. Registration Correlation, hierarchical MC, by RANSAC, by dynamic pro-gramming, by phase shift, MC active 7. 3D reconstruction by stereovision Triangulation: parallel system, convergent system without and with error; reconstruction to within a scale factor; recon-struction at a near projective transformation
Examination forms	100% Final exam
Study and examination require-ments	10/20
Reading list	Shapiro, L., & Stockman, G. (2001). Computer Vision. Pren-tice Hall, Upper Saddle River, NJ. Trucco, E., & Verri, A. (1998). Introductory Techniques for 3-D Computer Vision. Prentice Hall.

	Ballard, D. H., & Brown, C. M. (1982). Computer Vision. Prentice Hall, Englewood Cliffs, NJ. ISBN 0-13-165316-4 Baxes, G. A. (1994). Digital Image Processing: Principles and Applications. John Wiley & Sons, New York; Toronto. ISBN 0471009490 Castleman, K. R. (1996). Digital Image Processing. Prentice Hall. de Berg, M., van Kreveld, M., Overmars, M., & Schwarzkopf, O. (2000). Computational Geometry: Algorithms and Applications (2nd ed.). Springer-Verlag, Berlin, Germany.

ISA.5.1 Big data

Module designation	ISA.5.1 Big data
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Raoudha Chebil
Language	French
Relation to curriculum	Compulsory
Teaching methods	lesson, lab works, presentations.
Workload (incl. contact hours, self-study hours)	Total workload: 50h Contact hours: 30h (20h lessons + 10h lab works) Private study: 20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	Basic knowledge in programming (Python and Java) and relational databases
Module objectives/intended learning outcomes	Knowledge: Students: -Master the basic building blocks of the Hadoop platform, namely HDFS and MapReduce, and have an idea of the components of its ecosystem; -Master the MapReduce approach for problem solving; -Understand the limits of the relational model and know the different models of NOSQL databases. Competencies: C4, C7, C8
Content	Chapter I – Introduction to Big Data 1. Motivations 2. Definition 3. The 3Vs and the additional Vs 4. Benefits and challenges 5. Application examples 6. Stages of a Big Data project 7. New professions 8. Related fields Chapter II – Hadoop: Building Blocks 1. Hadoop presentation 2. Hadoop history 3. Hadoop ecosystem 4. HDFS 5. MapReduce V1 6. MapReduce V2 7. Design Patterns MapReduce Chapter III - Advanced Processing Tools 1. Data processing types 2. MapReduce review 3. Abstraction languages a. Pig b. Hive

	4. Apache Spark Chapter IV – NOSQL Databases 1. DBMS strengths 2. DBMS limits 3. BD NOSQL 4. BDR vs BD NOSQL 5. Study of BD NOSQL instances a. Cassandra b. MongoDB Chapter V – Big Data Architectures 1. Motivations 2. Lambda architecture 3. Kappa architecture 4. Other architectures 5. Case study Practical Works 1. Installation and testing of the working environment 2. HDFS 3. MapReduce 4. Pig and Hive 5. Spark 6. HBase
Examination forms	35% continuous evaluation (Lab works, presentations) ; 65% written exam
Study and examination requirements	10/20
Reading list	Mooc – "Fundamentals for Big Data", Télécom ParisTech – "Introduction to Hadoop and MapReduce", University Nice Sophia Antipolis Books Marr, B. (2015). Big Data: Using SMART big data, analytics and metrics to make better decisions and improve performance. John Wiley & Sons. Zikopoulos, P., Eaton, C., et al. (2011). Understanding big data: Analytics for enterprise class Hadoop and streaming data. McGraw-Hill Osborne Media. Classes Nerzic, P. (2016). Hadoop tools for Big Data. Rennes1 University, France.

AI.5.13 Machine and Deep Learning Workshops

Module designation	AI.5.13 Machine and Deep Learning Workshops
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Faouzi Ghorbel
Language	French
Relation to curriculum	optional
Teaching methods	lesson, lab works.
Workload (incl. contact hours, self-study hours)	Total workload:25h Contact hours :15h Private study:10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	• Machine Learning & Deep Learning • Basic Programming Skills (Matlab and Python)
Module objectives/intended learning outcomes	Students are able to: ● Know and understand the main architectures of neural networks, as well as their use in different scenarios. ● Effectively manipulate a framework for Deep Learning. ● Know the good practices around the resolution of Deep Learning problems, both on the optimization of the models and on their deployment in production. Competencies: C1, C2, C3, C4
Content	Workshop 1: Introduction to TensorFlow, Keras & PyTorch • Main notions in these frameworks • Performance, usage, popularity. • Criteria for choosing a framework for a given task. Workshop 2: One-layer fully connected network • Principle • Understanding in simple cases • Learning a simple curve • Learning on black and white images • Learning a probability distribution by maximizing likelihood • Interpretation of learned weights Adding Layers • Compromise number of neurons / number of layers • Initialization of network weights Workshop 3: CONVOLUTIONAL NEURON NETWORKS (CNN) Convolution: Intuition • Convolution: interpretations • Exact operation performed by a convolutional filter in the different frameworks • The various convolutional filters and options (strides, layers, etc.) • Effect of pooling: what do we get between the intermediate layers? Workshop 3: CONVOLUTIONAL NEURON NETWORKS FOR IMAGES • Convolution & 2D Pooling • Transfer Learning: make only part of the network learn. 1D convolutions for sound and sequences • Convolution & 1D Pooling • Interest and limitations

	Workshop 4: RECURRENT NEURON NETWORKS (RNN) Principles of RNN and different associated layers • Why do we need RNN? • Simple recurrent neural network • Long-Short Term Memory (LSTM) & Gated Recurrent Unit (GRU) Textual data processing • Text vectorization • Embedding • Apps • Classification of a sequence • Text generation Advanced Uses of RNNs • Stacking of RNN layers • Bi-directional RNN • Combination with convolutional layers Workshop 5: ADVANCED ARCHITECTURES OF NEURON NETWORKS • Interest and uses of auto-encoders • Examples of use • Information compression • Anomaly detection • Feature extraction Generating data with Generative Adversarial Networks (GANs) • Principle • Generation of image samples according to a probability distribution • Existing variants of GANs
Examination forms	100% Final exam
Study and examination requirements	10/20
Reading list	Bishop, C. M., & Nasrabadi, N. M. (2006). Pattern recognition and machine learning. New York: Springer. Murphy, K. P. (2012). Machine learning: A probabilistic perspective. MIT Press. Shalev-Shwartz, S., & Ben-David, S. (2014). Understanding machine learning: From theory to algorithms. Cambridge University Press. Nielsen, M. A. (2015). Neural networks and deep learning. San Francisco, CA, USA: Determination Press. Hastie, T., Tibshirani, R., Friedman, J. H., et al. (2009). The elements of statistical learning: Data mining, inference, and prediction. New York: Springer.

AI.5.14 Speech Recognition & chatbots Application

Module designation	CV.5.14 Speech Recognition&Chatbots Application
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Faouzi Ghorbel
Language	French
Relation to curriculum	optional
Teaching methods	Active approach (by problems and projects) Project integrated to the course "creation of an intelligent chatbot" + practical work
Workload (incl. contact hours, self-study hours)	Total workload:25h Contact hours :15h Private study:10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	- Signal processing - Foundations of Machine Learning, Linear Algebra - Python for Machine Learning - Python for Deep Learning
Module objectives/intended learning outcomes	This course aims to: - provide an overview of modern optimization methods for applications in machine learning and data science. - present, in particular, the framework and the theoretical and practical foundations of speech recognition Competencies: C1, C9
Content	Chapter 1 : Introduction to automatic speech recognition 1.1 Uses of automatic speech recognition 1.2The progress of the field over time 1.3 Challenges Chapter 2 : Overview of automatic speech recognition applications 2.1 Subtitling and automatic video translation 2.2 Indexing and information extraction in audiovisual documents 2.3 Human-computer voice interfaces. 2.4 Geolocation and mapping Chapter 3: Architecture of an Automatic Speech Recognition System 3.1 Acoustic model, 3.2 Language model 3.3 Pronunciation model 3.4 Decoder 4: Methods and metrics for evaluating automatic speech recognition systems 5: "Chatbots" project: Project progress: -Identification of the mission -Identification of the context -Setting up the scenario and the dialogic sequences -Development of the chatbot: from a chatbot creation platform such as AWS
Examination forms	100% Final exam
Study and examination requirements	10/20
Reading list	Amodei, D., Ananthanarayanan, S., Anubhai, R., Bai, J., Battenberg, E., Case, C., Casper, J., et al. (2016). Deep speech 2: End-

	to-end speech recognition in English and Mandarin. In International Conference on Machine Learning (pp. 173-182). Church, K. (2003). Speech and language processing: Where have we been and where are we going? Eurospeech'2003. Davidson, T., Bhattacharya, D., & Weber, I. (2019). Racial bias in hate speech and abusive language detection datasets. Third Workshop on Abusive Language Online. Hannun, A., et al. (2014). Deep speech: Scaling up end-to-end speech recognition. arXiv preprint arXiv:1412.5567. Hannun, A., Lee, A., Xu, Q., & Collobert, R. (2019). Sequence-to-sequence speech recognition with time-depth separable convolutions. arXiv preprint arXiv:1904.02619.

AI.5.15 Optimisation and Reinforcement Learning

Module designation	AI.5.15 Optimisation and Reinforcement Learning
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Faouzi Ghorbel
Language	French
Relation to curriculum	optional
Teaching methods	Active approach (by problems and projects)
Workload (incl. contact hours, self-study hours)	Total workload:25h Contact hours :15h Private study:10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	-Cloud. -Basic knowledge of Data Science/Machine Learning (statistics, algorithms). -Basic knowledge of Linux, network, -Python, bash.
Module objectives/intended learning outcomes	This course aims to: -provide an overview of modern optimization methods for applications in machine learning and data science. -discuss in theory and practice the scalability of algorithms to large data sets. -provides an introduction to the main models of reinforcement learning and its use in the optimization of machine learning (ML) and deep learning (DL) algorithms. Keywords: Deep learning, artificial neural networks, reinforcement learning, TD learning, SARSA Competencies: C1, C2, C3, C4
Content	Part 1: 1. General introduction to Reinforcement Learning 2. Markov decision processes and dynamic programming 3. Reinforcement learning algorithms: Introduction to stochastic approximation, TD(λ) and Q-learning algorithms 4. Dynamic programming with approximation: analysis in L∞ norm, Iteration on values with approximation, Iteration on policies with approximation, Minimization of Bellman residual, Analysis of some algorithms: LSTD, Bellman residual, LSPI, Fitted Q-iterations, Extension to analysis in Lp norm Part 2 5. variants of SARSA, Q-learning, n-step-TD learning 6. Political Gradient 7. Deep learning by reinforcement ● Exploration ● Actor-Critic networks ● Atari games and robotics ● Board games and planning ● sequences, recurrent networks, partial observability

Examination forms	100% Final exam
Study and examination requirements	10/20
Reading list	Espinasse, B., & Bellot, P. (2017). Introduction to Big-Data: Opportunity, storage and analysis of megadata. Dossiers Techniques de l'Ingénieur (DTI), Ref. H6040. Duchateau, F. (2014). Les SGBD Non-relationnels. Univ. Lyon 1. Chokogoue, J. (2017). Hadoop: Become operational in the world of Big Data (1st edition). ENI. Karau, H., Konwinski, A., Wendell, P., Zaharia, M. (2015). Learning Spark Lightning-Fast Big Data Analysis. O'Reilly Media. Delort, P. (2015). Le Big Data. Presses Universitaires de France. Lemberger, P., Batty, M., Morel, M., Raffeëlli, J. L. (2015). Big Data and Machine Learning. Dunod. Lacomme, P., Aridhi, S., Phan, R. (2014). Bases de données NoSQL et Big Data. Ellipses. Bruchez, R. (2013). Bases de données NoSQL. Ellipses. Bruchez, R. (2015). NoSQL databases and Big Data: Understanding and implementing. Eyrolles Publisher.

AI.5.16 Introduction to Natural Language Processing

Module designation	AI.5.16 Introduction to Natural Language Processing (NLP)
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Chiraz Ben Othmane Zribi
Language	French
Relation to curriculum	Optional
Teaching methods	e.g. lecture, lab works, project
Workload (incl. contact hours, self-study hours)	Total workload:25h Contact hours :15h Private study:10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	Students should have basic knowledge on programming with Python
Module objectives/intended learning outcomes	This course introduces the fundamental concepts and techniques of NLP by presenting the different levels of processing and giving a relatively broad overview of the the commonly used algorithms and tools. Objectives : Students will gain an in-depth understanding of the computational properties of natural languages and the commonly used algorithms for processing linguistic information. Learning Outcomes: The students will be able to: - Understand key concepts from NLP those are used to describe and analyze language - Understand POS tagging and context free grammar for Natural language - Understand semantic representation of Englisfh Natural language for processing Learning outcomes: C1, C8, C9 and C13
Content	1. Introduction - Overview of course content - Motivations and challenges of TAL - Examples of applications - Levels of analysis (oral and written) - Types of problems to solve - Approaches and techniques for NLP - Illustrative exercise 2. Morphological analysis - Presentation of the morphology (flexion, derivation) - Representation of morphology by lexical lists - Representation of morphology by finite state automata - Representation of morphology by automata with transducers 3. Morpho-synatxic labeling / POS-tagging - Definitions (morpho-synatxic labeling, label games,...) - Rule-based taggers (Example: Brill's taggerà - Probabilistic taggers (NGrams, based on hidden Markov chains) 4. Syntactic analysis and formal grammars - General presentation of syntactic analysis - Formal grammar: definition and types - Context free grammar for NLP - Syntax analysis with a context free grammar - Common parsing algorithms (CYK, Earley) 5. Processing semantics - General presentation of the semantics - Types of semantic relationships between words

	- Semantic similarity between words based on a thesaurus - Semantic similarity between words based on context - Semantic vectors and construction methods (LSA, Word2Vec) 6. Applications of NLP Spell-checking, Summarization , Question-Answering, improving user queries, Machine Translation– Overview.
Examination forms	Project
Study and examination requirements	10/20
Reading list	- Gunning, D. S. G. (2019). Natural Language Processing Fundamentals. Packt Publishing. - Indurkhya, N., & Damerau, F. J. (2010). Handbook of Natural Language Processing. - Jurafsky, D., & Martin, J. H. (2000). Speech and Language Processing. - Gelbukh, A. (2008). Computational Linguistics and Intelligent Text Processing.

CV.5.11 Medical Imaging Workshops

Module designation	CV.5.11 Medical Imaging Workshops
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Slim Mhiri
Language	French
Relation to curriculum	optional
Teaching methods	Active approach (by problems and projects)
Workload (incl. contact hours, self-study hours)	Total workload:25h Contact hours :15h Private study:10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	-Image processing -3D -Engineering mathematics.
Module objectives/intended learning outcomes	This course aims to: - introduce the specificities of medical images through their different acquisition methods, each time evoking the object and the different stages of their processing and the main problems encountered. - study the specificities of the different modalities. Learning outcomes: C1, C9
Content	Through workshops; This module addresses the following questions: Part 1. Introduction of the Image in medicine ● Clinical use of images ● Needs of the medical community ● Pathologies in the image ● Purpose of medical image processing ● Terms of acquisition Part 2 Modalities ● Ultrasound imaging (ultrasound) ● 3D ultrasound ● X-ray ● X-ray scanner (Computed tomography) ● CT imaging and artifacts ● Nuclear magnetic resonance imaging (MRI) ● PET-MRI complementarity ● Functional MRI ● X-ray angiography ● CT angiography ● MRI angiography Part 3.The main processing of medical images ● Segmentation ● Visualization ● Image merging ● Shape analysis ● Building Atlas ● Image series analysis ● Movement analysis ● Simulation ● Computer-assisted surgery
Examination forms	100% Final exam

Study and examination require-ments	10/20
Reading list	Farncombe, T., & Iniewski, K. (Eds.). (2017). Medical imaging: Technology and applications. CRC Press.

SEC.5.3 Blockchain

Module designation	SEC.5.3 Blockchain
Semester(s) in which the module is taught	S5
Person responsible for the module	Mohamed Houcine Hdhili, Hanen Idoudi
Teachers team	Hanen Idoudi
Language	French
Relation to curriculum	Optional
Teaching methods	Lesson, Lab works
Workload (incl. contact hours, self-study hours)	Total workload:25h Contact hours :15h (9h lessons, 6h lab works) Private study:10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	SEC.4.1 Cybersecurity and Cryptography
Module objectives/intended learning outcomes	Knowledge: After completing this course, students should be able to: • Explain blockchain and how it is applied across industries. • Describe key principles of blockchain technology and the benefits and value that they bring to enterprises. • Explain the role of a shared ledger. • Explain fundamental concepts in Hyperledger Fabric. • Describe the elements of a business network, the role of channels, and how the world state is maintained. • Develop, test, debug, and deploy chaincode with IBM Blockchain Platform Extension for Visual Studio Code • Apply concepts of blockchain security, identity and access control, and data privacy to blockchain solutions. • Write applications that interact with a blockchain network. • Describe patterns, best practices, and reference architectures for integration from enterprise applications to blockchain networks. Competencies: C6, C13
Content	Unit 1. Blockchain overview Unit 2. Introduction to chaincode development Unit 3. Chaincode query methods Unit 4. Best practices for writing, testing, and debugging chaincode Unit 5. Identity and access control Unit 6. Data privacy Unit 7. Basics of application development Unit 8. Blockchain integration and advanced application development
Examination forms	100% written exam
Study and examination requirements	10/20
Reading list	IBM Blockchain Developer – Official course material

DOS.5.3 IoT

Module designation	DOS.5.3 – IoT
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Hanen Idoudi
Language	French
Relation to curriculum	optional
Teaching methods	lecture, project
Workload (incl. contact hours, self-study hours)	Total workload:25h Contact hours :15h Private study:10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	Existing competences in networking
Module objectives/intended learning outcomes	The purpose of this course is to study the fundamental concepts of Internet of Things. At the end of the course, the students will be able: 1. Understand the basic concepts of Internet of Things (IoT) 2. Identify the main components of the IoT ecosystem 3. Explore the major applications in IoT 4. Understand the architecture and protocol stack proposed for IoT 5. Set up the specific requirements to design the logic and network architectures of an IoT application Competencies: C2, C3, C9
Content	Chapter I – Introduction to the Internet of Things - - The inception of IoT - - Basic concepts : smart objects, global connectivity, sensors, etc. - - IoT Ecosystem - - IoT challenges Chapter II – IoT Applications and architectures - - IoT Applications - - IoT architecture layers - - Connectivity models in IoT Chapter III – Networks technologies in IoT - IoT networks technologies classification - Long range communication networks overview - Short range communication networks overview Chapter IV – Middelwares and Application protocols for IoT

	- Web of Things: concepts and communication's models - WoT : Data Standards - IoT middelwares - Publish/subscribe model - WoT : Data exchange protocols - MQTT - CoAP Practical Work (personal project) : Design of a simple IoT application
Examination forms	Oral presentation of the personal project.
Study and examination requirements	To acquire at least 10/20 in the oral of the personal project
Reading list	Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (January 2015). Internet of Things: A Survey on Enabling Technologies, Protocols and Applications. IEEE Communications Surveys & Tutorials.

DOS.5.8 Introduction to cloud computing

Module designation	DOS.5.8: Introduction to Cloud Computing
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Dr. Mehrez Essafi
Teaching team	-
Language	French
Relation to curriculum	Optional
Teaching methods	• Lesson • Lab work
Workload (incl. contact hours, self-study hours)	Total workload: 25h Contact hours: 15h (12h lessons, 3h lab work) Private study: 10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	OS.2.1 Introduction to Operating systems and Unix environment NET.3.1 Local Networks NET.4.1 Computer Networks SE.4.2 Software Architecture SEC.4.1 Cybersecurity & cryptography
Module objectives/intended learning outcomes	• To understand the related architecture designs and technologies of cloud computing • To explain the overall architecture and key design principles of IoT systems, including both functional and non-functional aspects • To design cloud-based IoT applications using proper cloud services • To gain hands-on experience in key technologies for developing an IoT system, including sensor selection / interfacing, embedded system programming, use of suitable network protocols, and various cloud services (compute, storage, data analytics, management) • To gain design experience in solving a real-world problem using IoT and cloud technologies • To gain both the experience and confidence in learning a new IoT technology independently By the end of the course, students are expected to be able to: • Describe the IoT and Cloud architectures. • Deploy Cloud Services using different cloud technologies. • Implement cloud computing elements such virtual machines, web apps, mobileservices, etc. • Establish data migration techniques from IoT devices to the cloud. • Implement security features to protect data stored in the cloud. • Use visualisation techniques to show data generated from the IoT device. Competencies: C2, C3, C4, C5, C6, C13
Content	Unit 1 – Cloud Computing: main concepts • General introduction • Historical overview • Cloud characteristics • Business model • Advantages and limits Unit 2 – Data centers • Definitions • Main components • Green Computing • Security

	• High Availability Unit 3 – Cloud Services and deployment models • IaaS (Infrastructure as a Service) • PaaS (Platform as a Service) • SaaS (Software as a Service) • FaaS (Function as a Service) • Other services • Public Cloud • Private Cloud • Hybrid Cloud • Community Cloud Unit 4 – Virtualization • Definitions • Architectures • Solutions • Servers virtualization • Containers • Storage virtualization Unit 5 – Application of IoT & Cloud • IoT and cloud integration • Application development and cloud processing • Security and Privacy for IoT/Cloud Computing
Examination forms	• 20% labs • 80% written examination
Study and examination requirements	Student must achieve an overall minimum module mark of 10/20
Reading list	Mell, P., & Grance, T. (2011). The NIST Definition of Cloud Computing (800-145). National Institute of Standards and Technology (NIST). Duncan, C. H. (2017). Cloud computing gateway, cloud computing hypervisor, and methods. International Conference on Cloud Computing. Hennion, R., Tournier, H., & Bourgeois, E. (2014). Cloud computing: Décider - Concevoir - Piloter – Améliorer. Plouin, G. (2014). Cloud Computing, Sécurité, stratégie d'entreprise et panorama du marché. Collection InfoPro, Dunod. Rapport Cigref (2013). Fondamentaux du Cloud Computing: Le point de vue des Grandes Entreprises. Moyer, C. M. (2011). Building Applications in the Cloud: Concepts, Patterns, and Projects. Addison-Wesley. Marks, E. A., & Lozano, B. (2010). Executive's Guide to Cloud Computing. Wiley. Fagroud, F. Z., Benlahmar, E. H., Elfilali, S., & Toumi, H. (2019). IOT et Cloud Computing : état de l'art. Colloque sur les Objets et systèmes Connectés, Ecole Supérieure de Technologie de Casablanca (Maroc), Institut Universitaire de Technologie d'Aix-Marseille (France), Casablanca, Maroc. Odun-Ayo, I., Okereke, C., & Evwieroghene, O. (2018). Cloud Computing and Internet of Things - Issues and Developments. Christos, S., Kostas, P., Byung-Gyu, K., & Gupta, B. B. (2016). Secure Integration of Internet-of-Things and Cloud Computing. Future Generation Computer Systems.

	Vertiv (2018). L'impact du cloud et de l'internet des objets sur la demande en datacenters, Livre blanc et noir.

SE.5.3 Mobile Development

Module designation	SE.5.3 Mobile Development
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Sabri ALLANI
Teaching team	Sabri ALLANI
Language	French
Relation to curriculum	optional
Teaching methods	lab works and project.
Workload (incl. contact hours, self-study hours)	Total workload:25h Contact hours :15h (9h lesson, 6h lab works) Private study:10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	AP.2.1, AP.2.2 and DAT.2.1
Module objectives/intended learning outcomes	Key question: what learning outcomes should students attain in the module? Knowledge: ● have a good understanding of the mobile app's context ● have a basic knowledge of mobile dev frameworks ● have good knowledge of which standards apply to mobile application and related constraints. Competencies: C2, C3
Content	Introduction to mobile mobile app development Learn the basic principles of mobile app development using a cross-platform solution. Project ● Project Proposal: Conceptualize and design your project in the abstract and write a short proposal that includes the project description, expected data needs, timeline, and how you expect to complete it. ● Analysis and Planning: The application concept begins to develop at this point, after which it becomes a real mission. Definition of use cases and capture of comprehensive functional codes are the first steps in the assessment and planning strategy. ● UI / UX Design: A user-friendly interface is included in the UI/UX layout. The goal of the application product is to create a wholly mobile experience that is intuitive and straightforward to employ ● App Development: Concurrently with the prototype, the foundation stages of building an app are still essential. Before you begin writing your codes, make sure you've done this: ○ Specify the product backlog ○ Select a technology package ○ Set application's building goals A standard mobile application project consists of three major components: ○ Back-end/server technology ○ API(s) ○ The mobile app front-end
Examination forms	100% project eval
Study and examination requirements	10/20

Reading list	Alessandria, S. (2018). Flutter Projects: A practical, project-based guide to building real-world cross-platform mobile applications and games (Vol. 53). Packt Publishing. Nagy, R. (2022). Simplifying Application Development with Kotlin Multiplatform Mobile (Vol. 61). Packt Publishing.

Semester 5 Modules: Specialization Financial Engineering (Ingénierie pour la Finance - IF-)

code	Title	type	Coeffi-cients	ECTS	Total work-load	Contact hours	Private study
FIN.5.1	International Finance	compulsory	2	2	50	30	20
MAT.5.3	Numerical Optimization	compulsory	2	2	50	30	20
FIN.5.2	The Risk Modelling and Dynamic Financial Risk Management	compulsory	2	2	50	30	20
FIN.5.3	Bank Management	compulsory	2	2	50	30	20
ISA.5.1	Big Data	compulsory	2	2	50	30	20
FIN.5.4	Monte carlo methods and financial model simulation	compulsory	2	2	50	30	20
MAT.5.5	Data analysis	compulsory	2	2	50	30	20
MAT.5.4	Statistical Inference	optional	2	2	50	30	20
ISA.5.4	Business intelligence	optional	2	2	50	30	20
AI.5.1	Multi agent systems	optional	2	2	50	30	20
FIN.5.6	Valuation and financing of companies	compulsory	2	2	50	30	20
AI.5.12	Introduction to Deep Learning	compulsory	1	1	25	15	10
FIN.5.5	Quantitative Finance	compulsory	1	1	25	15	10
DOS.5.2	Blockchain	compulsory	1	1	25	15	10
SE.5.3	Mobile Development	optional	1	1	25	15	10
ISA.5.7	Distributed data Bases	optional	1	1	25	15	10
DOS.5.3	IoT	optional	1	1	25	15	10
	Module complémentaire 1		2	2	50	30	20
	Module complémentaire 2		2	2	50	30	20
	Module complémentaire 3		2	2	50	30	20
	Module complémentaire 4		1	1	25	15	10
	Module complémentaire 5		1	1	25	15	10
	Module complémentaire 6		1	1	25	15	10

FIN.5.1 International Finance

Module designation	FIN.5.1 International Finance
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Snoussi Imen
Teaching team	Snoussi Imen
Language	French
Relation to curriculum	Compulsory
Teaching methods	lesson
Workload (incl. contact hours, self-study hours)	Total workload: 50h Contact hours : 30h (15h lessons, 15h exercises) Private study: 20h.
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	Financial markets concepts
Module objectives/intended learning outcomes	To acquire a good knowledge of the functioning of the international monetary system, to understand the functioning of the spot and forward foreign exchange market, to understand the functioning of the operations on the various compartments of the foreign exchange market, to make known the various types of foreign exchange risks and the instruments which allow to cover them. Competencies: C11, C12, C13
Content	I. INTRODUCTION TO THE FOREIGN EXCHANGE MARKET : 1) History of the international monetary system 2) The exchange rate regime in Tunisia 3) Organisation of the international foreign exchange market 4) Participants in the foreign exchange market 5) The media used 6) Foreign exchange transactions II. THE FOREIGN EXCHANGE MARKET IN THE SPOT MARKET : 1) Definition and characteristics 2) Exchange rate quotation methods 3) The transition from rating with uncertainty to rating with certainty 4) The calculation of cross rates 5) Geographical arbitrage 6) Triangular arbitration (for the bank's own account and for the customer's account) III. THE FORWARD FOREIGN EXCHANGE MARKET 1) Definition and characteristics 2) Notions of carry forward and backwardation

	3) Forward foreign exchange market quotations 4) The mechanism for forming forward rates: forward outright exchange 5) Calculation of the forward price 6) The calculation of the forward price 7) Foreign exchange swaps IV. HEDGING CURRENCY RISK THROUGH CURRENCY OPTIONS 1) Origin and development of options markets 2) Over-the-counter markets 3) Organised markets 4) Calls/currencies 5) Puts/contracts 6) Determinants of currency options 7) The principle of hedging currency risk through currency options
Examination forms	35% continuous eval+65% written exam
Study and examination requirements	10/20
Reading list	Bourguinat, Teïletche, Dupuy. (2007). Finance internationale. Dunod. Krugman, P., & Obstfeld, M. (2012). International Economics (9th edition). Pearson.

MAT.5.3 Numerical Optimization

Module designation	MAT.5.3 Numerical Optimization
Semester(s) in which the module is taught	S:5
Person responsible for the module	Fethi Kadhi
Language	English
Relation to curriculum	Compulsory
Teaching methods	Lessons, Lab, Projects.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	MAT.3.1Linear and nonlinear programming MAT.2.2 Numerical methods
Module objectives/intended learning outcomes	Mathematical optimization or mathematical programming is the selection of a best element, with regard to some criterion, from some set of available alternatives. Optimization problems of sorts arise in all quantitative disciplines from computer science and engineeringto operations research and finance. the development of solution methods has been of interest in mathematics for centuries. R tool is a free open-source computing environment which works on several platforms such as Windows, Linux, and macOS. In recent years, there has been an increasing interest in using R software to perform the data analysis. Competencies: C1, C9, C13
Content	Ch:1 Basics of R 1.1 Data structures in R 1.2 Funtios in R 1.3 Decision-Making and Loop Statements 1.4 Graphics Ch:2 Optimality Conditions 2.1 First-Order Necessary Condition 2.2 Second-Order Necessary Condition 2.3 Second-Order Sufficient Condition Ch: 3 One-Dimensional Optimization Methods 3.1 Introduction 3.2 Golden Section Search Method 3.3 Newton–Raphson Method 3.4 Secant Method . Ch:4 Steepest Descent Method 4.1 Introduction 4.2 Basics of Steepest Descent Method 4.3 Steepest Descent Method for Quadratic Functions 4.4 Convergence Analysis of Steepest Descent Algorithm . Ch:5 Conjugate Gradient Methods

	5.1 Introduction 5.2 Basics of Conjugate Direction 5.3 Convergence Analysis of Conjugate Direction Method 5.4 Method of Conjugate Gradient Ch: 6 Newton's Method 6.1 Introduction 6.2 Newton's Method for Multiple Unknowns 6.3 Convergence Analysis of Newton's Method
Examination forms	35%Mid-term quiz + 65% Written final exam
Study and examination requirements	10/20;
Reading list	Mishra, S. K., & Ram, B. (2019). Introduction to Unconstrained Optimization with R. Springer. Gilli, M., Maringer, D., & Schumann, E. (2019). Numerical Methods and Optimization in Finance. Academic Press.

FIN.5.2 The Risk Modelling and Dynamic Financial Risk Management

Module designation	FIN.5.2 The Risk Modelling and Dynamic Financial Risk Management
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Mouna Ben Salah
Teaching team	Mouna Ben Salah
Language	French
Relation to curriculum	Compulsory
Teaching methods	Lesson
Workload (incl. contact hours, self-study hours)	Total workload: 50h Contact hours : 30h (21h lessons, 9 h exercises) Private study: 20h.
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	Portfolio management, financial market
Module objectives/intended learning outcomes	The Risk Modeling and Dynamic Financial Risk Management course aims to understand the concept of financial risk, and to provide information on the methods of measuring and managing this risk. This course will focus on market risk (equity market risk and interest rate risk related to movements in the term structure of interest rates). The classical methods of measuring this type of risk (standard deviation) as well as modern methods (Value at Risk or VaR) are studied. Next, this course will present the instruments used to hedge against market risk, namely: forwards, futures, options and swaps. At the end of this course, the student will acquire the necessary tools to identify measure and hedge financial risks. Competencies: C11, C12, C13

Content	Chapter 1: Financial Risk Assessment I: Measures of Financial Asset Risk II. Value at Risk 1. Definition of VaR 2. Historical VaR 3 Parametric VaR 3.1 Calculation of the VaR of a stock position or a stock portfolio 3.2 Calculation of the VaR of a currency position 3.3 Calculation of the VaR of a bond position 3.4 Aggregate VaR 3.5 portfolio VaR a. Marginal VaR b. Incremental VaR c. Individual VaR d. The VaR component 4. VaR by Monte Carlo simulation 5.The VaR of an option position 5.1 The VaR of a "Delta Normal" Option Position 5.2 VaR of a "Delta Gamma" Option Position 6. The expected short fall (ES) 7. Stressed VaR Chapter 2: Portfolio Insurance I. Definition of Options 1. The Call Option 2. The Put Option II. Uncovered Positions III. Portfolio Insurance 1. Stop-Loss Strategy 2. Option-based portfolio insurance 2.1 Put-based portfolio insurance 2.2 Call-based portfolio insurance 2.3 Cushion Method Insurance
	Chapter 4: Interest Rate Risk Management I. Definition II. Risk measurement: Gap analysis methods III. Hedging of interest rate risk and firm OTC instruments. 1. FRAs (Forward Rate Agreements) or rate guarantees 1.1 Definition 1.2 Mechanism 1.3 Calculation of the interest rate differential 2. The Forward Rate Agreement 1.1 Definition 1.2 Mechanism 1.3 Borrower forward 1.4 Lender forward 3. Interest rate swap IV. Hedging interest rate risk and conventional OTC instruments 1. The cap 2. The Floor 3. The Collar 3.1 The Borrowing Collar 3.2 The Lending Collar
Examination forms	35% continuous+65% written exam
Study and examination requirements	10/20

Reading list	Bellalah, M., & Simon, Y. (2000). Options, contrats à terme et gestion des risques: Analyse, évaluation et stratégies. Economica. Bellalah, M. (2003). Gestion des risques et produits dérivés classiques et exotiques. Gestion Sup, Dunod. Esch, L., Kieffer, R., & Lopez, T. (2003). Asset and Risk Management: La finance orientée « risques ». De Boeck et Larcier. Hull, J. (1997). Options, futures and other derivatives (3rd ed.). Prentice Hall. Roncalli, T. (2004). La Gestion des Risque Financiers. Economica. Simon, Y. (1995). Marchés dérivés de Matières Premières et Gestion du Risque de Prix. Economica. Simon, Y., & Bellalah, M. (2003). Options, contrats à terme et gestion des risques (2nd ed.). Economica. Simon, Y., Lautier, D., & Morel, C. (2009). Finance internationale (10th ed.). Economica. Vernimmen, P. (2002). Finance d'Entreprise. Dalloz.

FIN.5.3 Bank Management

Module designation	FIN.5.3 Bank Management
Semester(s) in which the module is taught	S5
Person responsible for the module (co-ordinator)	Mouna Ben Salah
Teaching team	Mouna Ben Salah
Language	French
Relation to curriculum	Compulsory
Teaching methods	Lesson
Workload (incl. contact hours, self-study hours)	Total workload: 50h Contact hours : 30h (20h lessons, 10h exercises) Private study: 20h.
Credit points	2 ECTS
Required and recommended prerequi-sites for joining the module	Financial analysis
Module objectives/intended learning outcomes	The Banking Management course aims to introduce students to the different types of banks and their respective businesses and to identify the risks they face through their activity (interest rate risk, market risk, credit risk, operational risk) and the mechanisms of credit risk management under the effect of tightening regulations and capital allocation requirements through the Basel I, Basel II and Basel III agreements ... Competencies: C11, C12, C13
Content	Chapter 1: Organization and functioning of the credit institution: the Tunisian banking system 1. Definition and mission of the credit institution 2. Rules of constitution 3. The three main areas of banking activity 4. Architecture of the Tunisian banking sector Chapter 2: Banking risks, definition and typology I. Typologies of banking risks 1. The credit risk 2. Market risk 3. Operational risk 4. Liquidity risk 5. Global Interest Rate Risk Chapter 3: The Regulatory Framework 1. History of the Basel Committee 2. Role of the Basel Committee 3. The Basel I agreement 4. The three pillars of the Basel II agreement 4.1 Minimum capital requirement 4.2 Prudential supervision process 4.3 Market discipline 5. The contributions of the Basel III agreement Chapter 4 : Credit risk management

	Section 1: Credit risk assessment I. The traditional approach to assessing credit risk: financial analysis II. The new approach to credit risk assessment 1. The credit scoring method 2. the Rating 3. RAROC: Risk Adjusted Return On Capital 4. Credit VaR 5. Measuring the credit risk of a bond portfolio
	Section 2. Credit risk management I. Traditional credit risk management instruments 1. Regulatory management 2. Guarantees 3. Provisioning II. New techniques 1. Securitization 2. Credit derivatives 2.1 Definition of credit derivatives 2.2 Credit Default Swaps (CDS) 2.3 Credits Linked Notes: "CLN 2.4 Total Return Swap: "TRS
Examination forms	35% continuous+65% written exam
Study and examination requirements	10/20
Reading list	Dumontier, P., & Dupré, D. (2005). Pilotage bancaire: Les normes IAS et la réglementation Bâle II. Revue Banque Editeur. Van Greuning, H., & Bratanovic, S. (2004). Analyse et Gestion du Risque Bancaire: Un cadre de référence pour l'évaluation de la gouvernance d'entreprise et du risque financier. ESKA. Coussergues, S., & Bourdeaux, G. (2013). Gestion de la banque du diagnostic à la stratégie. Dunod. Banque des règlements internationaux. (2017). Bâle III: Finalisation des réformes de l'après-crise.

ISA.5.1 Big Data

Module designation	ISA.5.1 Big Data
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Raoudha Chebil
Language	French
Relation to curriculum	Compulsory
Teaching methods	lesson, lab works, presentations.
Workload (incl. contact hours, self-study hours)	Total workload: 50h Contact hours: 30h (20h lessons + 10h lab works) Private study]: 20 h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	DAT.1.1 Database and DBMS
Module objectives/intended learning outcomes	Knowledge: Students: -Master the basic building blocks of the Hadoop platform, namely HDFS and MapReduce, and have an idea of the components of its ecosystem; -Master the MapReduce approach for problem solving; -Understand the limits of the relational model and know the different models of NOSQL databases. Competencies: C4, C7, C8

Content	Chapter I – Introduction to Big Data 1. Motivations 2. Definition 3. The 3Vs and the additional Vs 4. Benefits and challenges 5. Application examples 6. Stages of a Big Data project 7. New professions 8. Related fields Chapter II – Hadoop: Building Blocks 1. Hadoop presentation 2. Hadoop history 3. Hadoop ecosystem 4. HDFS 5. MapReduce V1 6. MapReduce V2 7. Design Patterns MapReduce Chapter III - Advanced Processing Tools 1. Data processing types 2. MapReduce review 3. Abstraction languages a. Pig b. Hive 4. Apache Spark Chapter IV – NOSQL Databases 1. DBMS strengths 2. DBMS limits 3. BD NOSQL 4. BDR vs BD NOSQL 5. Study of BD NOSQL instances a. Cassandra b. MongoDB Chapter V – Big Data Architectures 1. Motivations 2. Lambda architecture 3. Kappa architecture 4. Other architectures 5. Case study Practical Works 1. Installation and testing of the working environment 2. HDFS 3. MapReduce 4. Pig and Hive 5. Spark 6. HBase
Examination forms	35% continuous evaluation (Lab works, presentations) ; 65% written exam
Study and examination require-ments	10/20

Reading list	Mooc − "Fundamentals for Big Data", Télécom Paris-Tech − "Introduction to Hadoop and MapReduce", University Nice Sophia Antipolis Books Bruchez, R. (2015). NoSQL databases and BigData: Understanding and implementing. Editions Eyrolles. Marr, B. (2015). Big Data: Using SMART big data, analytics and metrics to make better decisions and improve performance. John Wiley & Sons. Zikopoulos, P., Eaton, C., et al. (2011). Understanding big data: Analytics for enterprise class Hadoop and streaming data. McGraw-Hill Osborne Media. Classes Nerzic, P. (2016). Hadoop tools for Big Data. Rennes1 University, France.

FIN.5.4 Monte carlo methods and financial model simulation

Module designation	FIN.5.4 Monte Carlo Methods & Simulation of Financial Models
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Amor Oueslati
Teaching team	
Language	French
Relation to curriculum	Compulsory
Teaching methods	lecture, lab works
Workload (incl. contact hours, self-study hours)	Total workload: 50h Contact hours: 30h (20h lessons, 10h lab works) Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	Probability, inferential statistics, Bayesian statistics, stochastic calculus, stochastic process, Financial Mathematics
Module objectives/intended learning outcomes	Competencies: C1, C9, C13
Content	1. Introduction to Monte Carlo Simulation 2. Simulation of random variables 3. Simulation of Diffusion Processes & Time Discrete Methods 4. Variance reduction techniques: - antithetic variable, control

	variable and pairing of moments - Strategic sampling, Stratified sampling, and Latin hypercube 5. Option pricing and value-at-risk estimation 6. Model estimation and calibration 7.MCMC
Examination forms	35% continuous evaluation (Lab works, presentations) ;65% written exam
Study and examination requirements	Requirements for successfully passing the module
Reading list	Glasserman, P. (2003). Monte Carlo Methods in Financial Engineering (Stochastic Modelling and Applied Probability) (v. 53). Springer-Verlag New York, LLC. Lamberton, D., & Lapeyre, P. (1999). Introduction au calcul stochastique appliqué à la finance. Ellipses. Rennie, A. (1996). Financial Calculus: An Introduction to Derivative Pricing. Cambridge University Press. Steele, J. M. (2003). Stochastic Calculus and Financial Applications. Springer-Verlag New York, LLC. Duffie, D. (1992). Dynamic Asset Pricing Theory. Princeton University Press. Karatzas, I., & Shreve, S. E. (1988). Brownian Motion and Stochastic Calculus. Springer.

MAT.5.5 Data analysis

Module designation	MAT.5.5 Data Analysis
Semester(s) in which the module is taught	Sem:5
Person responsible for the module	Fethi Kadhi
Language	French
Relation to curriculum	Compulsory
Teaching methods	Lessons, Lab, Projects.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	MAT.1.1 Probabilty and statstics
Module objectives/intended learning outcomes	The emphasis in this course is on financial data and how to model and analyze it. Understanding financial data may increase one's success in the markets Competencies:C1, C9
Content	1. The Nature of Financial Data 1.1 Financial Assets and Markets 1.2 Frequency Distributions of Returns 1.3 Volatility 2. Exploratory Financial Data Analysis 2.1. Data Reduction 2.2. The Empirical Cumulative Distribution Function 2.3. Graphical Methods in Exploratory Analysis 3. Statistical Models and Methods of Inference 3.1. Models 3.2. Optimization in statistics 3.3. Properties of estimators 4. Regression Models 4.1. Linear regression model 4.2. Nonlinear models 4.3. ARMA and ARIMA Models
Examination forms	100% final exam
Study and examination requirements	10/20

Reading list	Collard, J.-F. Hands-On Data Analysis in R for Finance. CRC Press (Taylor & Francis Group, LLC). DOI: 10.1201/9781003320555.

MAT.5.4 Statistical Inference

Module designation	MAT.5.4 Statistical inference
Semester(s) in which the module is taught	Sem:5
Person responsible for the module	Fethi Kadhi
Language	French
Relation to curriculum	Optional
Teaching methods	Lessons, Lab, Projects.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	MAT.1.1 Probabilty and statstics
Module objectives/intended learning outcomes	In a statistical investigation, it is known that for reasons of time or cost, one may not be able to study each individual element of the population. In such a situation, a random sample should be taken from the population, and the inference can be drawn about the population on the basis of the sample. Hence, statistics deals with the collection of data and their analysis and interpretation. In this book, the problem of data collection is not considered. We shall take the data as given, and we study what they have to tell us. The main objective is to draw a conclusion about the unknown population characteristics on the basis of information on the same characteristics of a suitably selected sample. Competencies:C1, C9
Content	1. Basics of R 1.1 Types of R 1.2 Data structures of R 1.3 Functions in R 2. Theory of Sampling 2.1. Samples 2.2. Weak law of great numbers 2.3. Limit central theorem 2.4. Gamma, Student, Fisher Distributions 3. Point estimates 3.1. Moments method 3.2. Likelihood method 3.3. Properties of estimators 4. Confidence intervals 4.1. Confidence interval of a proportion 4.2. Confidence interval of a mean 4.3. Confidence interval of a variance 5. Hypothesis tests 5.1. Tests of conformity 5.2. Tests of comparison 5.3. One-Way Analysis of Variance (ANOVA)

	6. Regression: Fitting a Straight Line 6.1. Least Squares Regression 6.2. Properties of the Least Squares Estimators 6.3 Estimating the Error Variance r
Examination forms	100% final exam
Study and examination requirements	10/20
Reading list	Bartoszynski, R., & Niewiadomska-Bugaj, M. (2020). Probability and Statistical Inference, Third Edition. Wiley-Interscience. Deshmukh, S., & Kulkarni, M. (2021). Asymptotic Statistical Inference: A Basic Course Using R. Springer.

ISA.5.4 Business intelligence

Module designation	ISA.5.4 Business intelligence
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Manel BenSassi
Language	French
Relation to curriculum	Optional
Teaching methods	lesson, lab works.
Workload (incl. contact hours, self-study hours)	Total workload: 50H Contact hours:30h (21H lesson, 09H Lab works). Self study: 20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	DAT.1.1 Database and DBMS
Module objectives/intended learning outcomes	This course refers to technologies, applications and practices of heterogeneous data integration, storage, multidimensional analysis, and visualization to support business decision making. Thus, the student will be able to propose concrete conceptual and technological architecture for the integration od heterogenous data in the professional environment as he will acquire many competencies such as: - Become able to evaluate the technologies that make up BI (data Warehousing, OLAP) - Become able to plan the implementation of a BI architecture. Learning outcomes: C1, C2, C3, C4, C8, C9
Content	Chapter 1 : Understanding Business intelligence - The challenge of decision making - What is business intelligence - The BI value chain and value Chapter 2: Data Integration - Data integration motivation - ETL Process - ETL techniques Chapter 3: Data Storage: Data Warehousing - What is data warehousing? - Data Marts and analytical Data - Organization of DataWarehouse - Data access Chapter 4: Multi dimensional Analysis with OLAP - Definitions - OLAP vs OLTP - Operational data stores - Multi-Dimensions techniques - OLAP architecture Chapter 5 : MDX Language - Problem presentation - MDX Syntax and Request
Examination forms	35% Continues evaluation + 75% Written exam
Study and examination requirements	10/20

Reading list	**Fernandez, A. (2013). Les nouveaux tableaux de bord des managers: Le projet Business intelligence clés en main (6th ed.). Eyrolles.** **Fernandez, A. (2013). L'essentiel du tableau de bord: Concevoir le tableau de bord de pilotage avec Microsoft Excel (4th ed.). Eyrolles.** **Galzy, C., Girona, P., Martin, B., Nicoloso, C., & Vandermoere, J. (May 2010). La Business Intelligence, Livre Blanc.**

AI.5.1 Multi agent systems

Module designation	AI.5.1 MultiAgent Systems
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Narjès Bellamine Ben Saoud
Language	French/English
Relation to curriculum	Compulsory
Teaching methods	lesson, lab works, project, seminar.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended pre-requisites for joining the module	SE.3.1 Software Engineering AI.3.1
Module objectives/intended learning outcomes	- Master the concepts of agent and multi-agent systems - Study and apply a design methodology for a multi-agent system. - Learn the development of a multi-agent system - Explore complementary research questions Competencies: C1, C7
Content	Chapter 1: Introduction to MAS Chapter 2: Intelligent Agents Chapter 3: Agents architectures Chapter 4: Methodologies for developing multi-agent systems Chapter 4: MAS Development environments & case study
Examination forms	35% Continues evaluation + 65% Written exam
Study and examination requirements	10/20
Reading list	Ferber, J. (1995). Les systèmes multi-agents. InterEditions. Wooldridge, M. (2002). An Introduction to MultiAgent Systems. Wiley. Russell, S., & Norvig, P. (2006). Intelligence Artificielle (2nd ed., 2ème Chapitre). Pearson Education France. Russell, S., & Norvig, P. (2020). Artificial Intelligence: A Modern Approach (4th ed.). Pearson.

FIN.5.6 Valuation and financing of companies

Module designation	FIN.5.6 Valuation and financing of companies
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Snoussi Imen
Teaching team	Snoussi Imen
Language	French
Relation to curriculum	Compulsory
Teaching methods	lesson
Workload (incl. contact hours, self-study hours)	Total workload:25h Contact hours :15h Private study:10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	
Module objectives/intended learning outcomes	This course aims to present mathematical methods adapted to the interests of engineering students in the constantly evolving fields of analysis, processing, filtering and estimation of data as a support for information. • In the first part, it aims to introduce, on a mathematical level, the concepts of measurement theory, distributions, convolution and Fourier analysis of signals. • Secondly, a series of practical work sessions using Matlab constitutes a first contact for our engineering students with this programming language which allows them to better understand certain theoretical aspects related to the processing of speech, images and digital transmission. Competencies: C11, C12, C13
Content	I. Investment decision in a context of certainty : 1) The criteria for evaluating the profitability of a project (Van, IRR, DR...) 2) Calculation of investment parameters 3) Calculation of cash flows 4) Study of conflicting NPV and IRR cases (NPV replicated to infinity, equivalent annuity) II. Investment decision in a context of risk and uncertainty : 1) Projects that are independent of the company's activity (Use of cash flow distribution, Use of NPV distribution: Decision tree technique) 2) Projects that are integrated into the company's activities III. Financing choices :

	1) Definition of the Weighted Average Cost of Capital 2) The cost of the various sources of financing (common shares, preferred shares, bank loans, bonds...) 3) Formal expression of the Weighted Average Cost of Capital (choice of weights...) 4) The impact of debt on the risk and return on common equity (financial leverage, optimal capital structure....)
Examination forms	35% continuous eval+65% written exam
Study and examination requirements	10/20
Reading list	Vernimmen, P. (2020). Finance d'entreprise (19th ed.). Dalloz books. Pilverdier, J., Gillet, P., Guidici, S., & Vinhas Pereira, C. (2016). Finance d'entreprise (9th ed.). Economica. Le Gros, G. (2018). Finance d'entreprise (3rd ed.). Dunod.

AI.5.12 Introduction to Deep Learning

Module designation	AI.5.12 Introduction to Deep Learning
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Rym Besrour
Teaching team	Rym Besrour
Language	French
Relation to curriculum	Compulsory
Teaching methods	Lesson and project
Workload (incl. contact hours, self-study hours)	Total workload:25h Contact hours :15h Private study:10h
Credit points	1 ECTS
Required and recommended pre-requisites for joining the module	MAT.1.1: Probability and Statistics AI .3.1.: IA & Machine Learning Students must be competent in python.
Module objectives/intended learning outcomes	Knowledge: ● Understand generic machine learning terminology ● Understand motivation and functioning of the most common types of deep neural networks ● Understand the choices and limitations of a model for a given setting ● Apply deep learning techniques to practical problems ● Critically evaluate model performance and interpret results Competencies: C1, C9

Content	Introduction Chapter1:Applied Math and Machine Learning Basics ● Linear Algebra ● Probability and Information Theory ● Numerical Computation ● Machine Learning Basics Chapter2:Modern Practical Deep Networks ● Deep Feedforward Networks ● Regularization for Deep Learning ● Optimization for Training Deep Models ● Convolutional Networks ● Sequence Modeling: Recurrent and Recursive Nets ● Practical Methodology ● Applications Chapter3 :Deep Learning Research ● Autoencoders ● Deep Generative Models Projects ideas : ● Smart routing ● Smart home security ● Smart energy managment
Examination forms	100% project evaluation
Study and examination requirements	10/20
Reading list	Géron, A. (2020). Deep Learning avec Keras et TensorFlow (2e édition). Dunod. Charniak, E. (2021). Introduction au Deep Learning. Dunod.

FIN.5.5 Quantitative Finance

Module designation	FIN.5.5 Quantitative Finance
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Mouna Ben Salah
Teaching team	Mouna Ben Salah
Language	French
Relation to curriculum	Compulsory
Teaching methods	Lesson
Workload (incl. contact hours, self-study hours)	Total workload: 25h Contact hours : 15h (10h lessons, 5h exercises) Private study: 10h.
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	Stochastic calculus, differential equations. Portfolio Management.
Module objectives/intended learning outcomes	The objective of the Numerical Optimization Methods in Finance course is to introduce students to the most commonly used numerical methods in finance and mainly to the numerical methods used in the valuation of derivative products. Competencies:C11, C12, C13
Content	Chapter 1: The Discrete-Time Option Pricing Model: the Cox Ross and Robinstein model (1985) I. The one Period Binomial Model 1. Call options 2. Put options II. Extension of the model to two periods III. Generalization of the binomial formula to n periods IV. Dynamic hedging V. Taking dividends into account 1. Case of a known proportional dividend 2. Case of a known dividend amount Chapter 2: Option Pricing in Continuous Time: The Black-Scholes Model I. Black-Scholes partial derivative equation 1. Assumptions 2. Itô's lemma 4. The Black-Scholes valuation formula II. The Greek letters 1. The delta 2. The gamma 3. Theta 4. The Vega 5. The Rho III. The dynamic hedging 1. The delta hedging 2. The delta gamma hedging

	3. Delta vega hedging 4. The delta gamma vega hedging
Examination forms	100% written exam
Study and examination requirements	10/20
Reading list	Bellalah, M. (2003). Gestion des risques et produits dérivés classiques et exotiques. Collection: Gestion Sup. Dunod. François, P. (2005). Les produits dérivés financiers: Méthodes d'évaluation. Dunod. Hull, J. (1997). Options, futures and other derivatives (3rd ed.). Prentice Hall. Huu Tue, H., Van Son L., Issouf S. (2006). Simulation Stochastiques et application en finance avec programmation Matlab. Economica. Khoury, N., Laroche, P., & François, P. (2010). Introduction aux instruments financiers dérivés. Les presses de l'université Laval, Québec. Racicot, F., & Théoret, R. (2006). Finance computationnelle et gestion des risques: Ingénierie financière avec applications Excel et Matlab. Les presses de l'université Laval, Québec.

DOS.5.2 Blockchain

Module designation	DOS.5.2 Blockchain
Semester(s) in which the module is taught	S5
Person responsible for the module	Mohamed Houcine Hdhili, Hanen Idoudi
Teachers team	Hanen Idoudi
Language	French
Relation to curriculum	Optional
Teaching methods	Lesson, Lab works
Workload (incl. contact hours, self-study hours)	Total workload:25h Contact hours): 15h (9h lesson, 6h lab works) Private study:in hours: 10h
Credit points	1 ECTS
Required and recommended prereq-uisites for joining the module	SEC.4.1 Cybersecurity and Cryptography
Module objectives/intended learning outcomes	Knowledge: After completing this course, students should be able to: • Explain blockchain and how it is applied across industries. • Describe key principles of blockchain technology and the bene-fits and value that they bring to enterprises. • Explain the role of a shared ledger. • Explain fundamental concepts in Hyperledger Fabric. • Describe the elements of a business network, the role of chan-nels, and how the world state is maintained. • Develop, test, debug, and deploy chaincode with IBM Block-chain Platform Extension for Visual Studio Code • Apply concepts of blockchain security, identity and access con-trol, and data privacy to blockchain solutions. • Write applications that interact with a blockchain network. • Describe patterns, best practices, and reference architectures for integration from enterprise applications to blockchain networks. Competencies: C6, C13
Content	Unit 1. Blockchain overview Unit 2. Introduction to chaincode development Unit 3. Chaincode query methods Unit 4. Best practices for writing, testing, and debugging chaincode Unit 5. Identity and access control Unit 6. Data privacy Unit 7. Basics of application development Unit 8. Blockchain integration and advanced application develop-ment
Examination forms	100% written exam

Study and examination requirements	10/20
Reading list	IBM Blockchain Developer – Official course material

SE.5.3 Mobile Development

Module designation	SE.5.3 Mobile Development
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Sabri ALLANI
Teaching team	Sabri ALLANI
Language	French
Relation to curriculum	Compulsory
Teaching methods	lab works and project.
Workload (incl. contact hours, self-study hours)	Total workload: 25h Contact hours : 15h Private study : 10h
Credit points	1 ECTS
Required and recommended pre-requisites for joining the module	AP.2.1, AP.2.2 and DAT.2.1
Module objectives/intended learning outcomes	Key question: what learning outcomes should students attain in the module? Knowledge: · have a good understanding of the mobile app's context · have a basic knowledge of mobile dev frameworks · have good knowledge of which standards apply to mobile application and related constraints. Competencies: C2, C3

Content	Introduction to mobile mobile app development Learn the basic principles of mobile app development using a cross-platform solution. Project · Project Proposal: Conceptualize and design your project in the abstract and write a short proposal that includes the project description, expected data needs, timeline, and how you expect to complete it. · Analysis and Planning: The application concept begins to develop at this point, after which it becomes a real mission. Definition of use cases and capture of comprehensive functional codes are the first steps in the assessment and planning strategy. · UI / UX Design: A user-friendly interface is included in the UI/UX layout. The goal of the application product is to create a wholly mobile experience that is intuitive and straightforward to employ · App Development: Concurrently with the prototype, the foundation stages of building an app are still essential. Before you begin writing your codes, make sure you've done this: o Specify the product backlog o Select a technology package o Set application's building goals A standard mobile application project consists of three major components: o Back-end/server technology o API(s) o The mobile app front-end
Examination forms	100% project eval
Study and examination requirements	10/20
Reading list	Alessandria, S. (2018). Flutter Projects: A practical, project-based guide to building real-world cross-platform mobile applications and games (Vol. 53). Packt Publishing. Nagy, R. (2022). Simplifying Application Development with Kotlin Multiplatform Mobile (Vol. 61). Packt Publishing.

ISA.5.7 Distributed databases

Module designation	ISA.5.7 Distributed Databases
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Raoudha KHCHERIF
Language	French
Relation to curriculum	Compulsory
Teaching methods	lecture, lesson, assignment, labs
Workload (incl. contact hours, self-study hours)	Total workload: 25h Contact hours: 15h Private study: 10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	DAT.2.1 , DAT.2.2, NET3.1, NET3.2, NET4.1
Module objectives/intended learning outcomes	This course will deal with the fundamental issues in large distributed database systems which are motivated by the computer networking and distribution of processors, and control. The theory, design, specification, implementation, and performance of large systems will be discussed. Competencies: C1, C2, C8, C13
Content	I INTRODUCTION II. BDR DESIGN AND IMPLEMENTATION II. TRANSACTION AND COMPETITOR ACCESS IV. OPTIMIZATION OF DISTRIBUTED QUERIES
Examination forms	100% written Exam
Study and examination requirements	10/20
Reading list	Özsu, M. T., & Valduriez, P. (2011). Principles of Distributed Database Systems. Springer. Rahimi, S. K. (2010). Distributed Database Management Systems. John Wiley & Sons Inc.

DOS.5.3 IoT

Module designation	DOS.5.3 IoT
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Hanen Idoudi
Language	French
Relation to curriculum	Compulsory
Teaching methods	lecture, project
Workload (incl. contact hours, self-study hours)	Total workload: 25h Contact hours: 15h Private study: 10h
Credit points	1 ECTS
Required and recommended pre-requisites for joining the module	Existing competences in networking
Module objectives/intended learning outcomes	The purpose of this course is to study the fundamental concepts of Internet of Things. At the end of the course, the students will be able: 1. Understand the basic concepts of Internet of Things (IoT) 2. Identify the main components of the IoT ecosystem 3. Explore the major applications in IoT 4. Understand the architecture and protocol stack proposed for IoT 5. Set up the specific requirements to design the logic and network architectures of an IoT application Competencies: C2, C3, C9

Content	Chapter I – Introduction to the Internet of Things - - The inception of IoT - - Basic concepts : smart objects, global connectivity, sensors, etc. - - IoT Ecosystem - - IoT challenges Chapter II – IoT Applications and architectures - - IoT Applications - - IoT architecture layers - - Connectivity models in IoT Chapter III – Networks technologies in IoT - IoT networks technologies classification - Long range communication networks overview - Short range communication networks overview Chapter IV – Middelwares and Application protocols for IoT - Web of Things: concepts and communication's models - WoT : Data Standards - IoT middelwares - Publish/subscribe model - WoT : Data exchange protocols - MQTT - CoAP Practical Work (personal project) : Design of a simple IoT application
Examination forms	Oral presentation of the personal project.
Study and examination requirements	To acquires at least 10/20 in the oral of the personal project
Reading list	Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (January 2015). Internet of Things: A Survey on Enabling Technologies, Protocols and Applications. IEEE Communications Surveys & Tutorials.