

# MASTER IN ARTIFICIAL INTELLIGENCE (AI)

## Main Language of Instruction:

French: <input type="checkbox"/>	English: <input checked="" type="checkbox"/>	Arabic: <input type="checkbox"/>
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## Campus Where the Program Is Offered: CST

## Objectives

The Master's degree in Artificial Intelligence (AI) is a professional program to prepare experts capable of developing intelligent programs and systems to be implemented in different industries for the betterment of mankind. Our graduates have expertise in a wide range of AI-related fields such supervised and unsupervised Machine Learning (ML) and Deep Learning (DL), Reinforcement Learning, Big Data Analysis and Modeling, Data Mining, Statistics as well as the development of parallel and distributed AI-based software. It is a professional master program that meets the needs of the job market but also provides the theoretical basis that enables students to pursue doctoral studies in this field. The program features theoretical & practical lectures, extensive hands on experience and an internship in a company or a research internship leading to the writing of a thesis and a defense. Our graduates are presented with a wide range of opportunities in the fields of Machine Learning (ML), Deep Learning (DL), Computer Vision (CV), Natural Language Processing (NLP), Generative AI (GenAI), Large Language Models (LLM), Internet of Things (IoT) with applications in software development, robotics, healthcare, fintech and others.

## Program Learning Outcomes (Competencies)

Student Outcomes (SO)	Performance Indicators (PI)
1. Acquire and apply advanced knowledge appropriate to the discipline	1.1: Acquire theoretical and practical concepts appropriate to the discipline 1.2: Demonstrate proficiency in applying theoretical concepts to practical problems within the discipline
2. Solve critical issues and demonstrate expertise in key areas in the field of study	2.1: Identify and evaluate key challenges in the field 2.2: Solve critical issues by using advanced mathematics and sciences 2.3: Exhibit depth of knowledge in specialized areas
3. Analyze, and think innovatively to develop novel solutions for real-world problems	3.1: Generate original ideas and approaches to solving practical problems 3.2: Apply analytical thinking and innovative methodologies to develop new solutions 3.3: Assess the feasibility of proposed solutions using appropriate methods 3.4: Evaluate the impact of proposed solutions in social, economic and environmental context
4. Apply new and diversified theoretical and experimental methods as appropriate to the discipline	4.1: Demonstrate the ability to learn and apply new methods and technologies 4.2: Utilize advanced analytical tools and techniques to solve complex issues in the field 4.3: Integrate new technologies into existing systems to improve performance
5. Integrate ethics and moral responsibility in engineering solutions in the field	5.1: Identify ethical issues in engineering practice and propose responsible solutions 5.2: Evaluate the social and environmental impact of engineering projects and decisions 5.3: Incorporate ethical considerations into the design and implementation of engineering solutions
6. Conduct independent, original research and contribute to the advancement of knowledge in the field	6.1: Formulate research questions that address gaps in current knowledge 6.2: Implement research methodologies appropriate to the discipline 6.3: Collect relevant data by applying processing techniques 6.4: Analyze and interpret data using advanced techniques
7. Communicate, at an advanced level, in oral and written form	7.1: Prepare clear, concise, and well-organized written reports on complex topics 7.2: Deliver effective oral communications, demonstrating mastery of the subject matter
8. Recognize the importance of standards of professional integrity	8.1: Perceive professional standards and codes relevant to the field 8.2: Demonstrate professional responsibilities in all activities

## **Admission Requirements**

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Admission of students is based on their application form, supporting documents and a potential interview.

### **1- Admission to the first semester of the Master's program (S1)**

To be authorized to apply, students must satisfy one of the following conditions:

- Hold a BS Degree in Computer and Communications engineering, or Computer Science, telecommunications,
- Hold an equivalent Degree recognized by USJ.

### **2- Admission to the third semester of the Master's program (S3)**

To be authorized to apply, students must satisfy one of the following conditions:

- Hold a BE Degree in Computer and Communications Engineering or being a CCE Program Student at ESIB and earned at least 120 credits in Engineering Cycle.
- Hold a Master Degree in Computer Science, or Computer and Communication, or Informatics.
- Hold an equivalent Degree recognized by USJ.

The application form should be downloaded from USJ's website<sup>1</sup>, printed and delivered along with supporting documents to:

Faculty of Engineering and Architecture (FIA) at ESIB – USJ  
Campus des Sciences et Technologies (CST), Mar Roukos, Mkalles  
Tel: (01) 421 316/7/8  
Email : [secretariat.esib@usj.edu.lb](mailto:secretariat.esib@usj.edu.lb)

The selected candidates might be interviewed before their final admission.

## **Courses/Credits Granted by Equivalence**

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### **1. Students admitted to M1:**

Depending on their profile, Engineering students who are admitted to M1 can be granted the below courses by equivalence:

- Statistics for AI & Machine Learning (020IASTM1)
- Mathematics for AI & Machine Learning (020IAMAM1)

Electrical engineering students at ESIB who are admitted to M1 can additionally be granted the below course by equivalence:

- AI based Control Systems (020IARBM3)

Other cases will be treated on a case by case basis.

### **2. Students admitted to M2:**

Depending on the elective courses they have taken, ESIB Computer and Communications Engineering students admitted to M2 can be granted the below courses by equivalence:

- Big Data Frameworks (020BDFRM3)
- Generative AI (020GAIES5)
- Software Engineering for AI (020IAIDM3)

Note that, to be eligible for admission directly to M2, ESIB CCE engineering students are required to take three of the below elective courses before graduating from the engineering program:

- 020IA2ES4 - Artificial Intelligence.
- 020MLRES4 - Machine Learning.
- 020MMDES4 - Mining Massive Datasets.
- 020TIMES4 - Traitement d'images (Computer Vision)

Other cases will be treated on a case by case basis.

## **Program Requirements**

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### **Required Courses (120 Cr.)**

Artificial Intelligence (4 Cr.), Graph Theory and Operations Research (4 Cr.), Mathematics for AI & Machine Learning (4 Cr.), Natural Language Processing (4 Cr.), Optimization for AI (4 Cr.), Programming for AI & Machine Learning (6 Cr.), Statistics for AI & Machine Learning (4 Cr.), AI in Computer Vision (4 Cr.), AI in Financial Technology (4 Cr.), AI in Robotics (4 Cr.), Game Theory (4 Cr.), Foundations of Decision Modeling (5 Cr.), Machine Learning (4 Cr.), Parallel Computing (5 Cr.), AI-Based Control Systems (4 Cr.), AI for Business and Marketing (6 Cr.), AI in Cybersecurity (4 Cr.), Big Data Frameworks (4 Cr.), Generative AI (4 Cr.), Legal, Policy, and Ethical Considerations for Data Scientists and AI (4 Cr.), Software Engineering for AI (4 Cr.), Master's Thesis (30 Cr.)

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<sup>1</sup> <https://usj.edu.lb/esib/diplome.php?diplome=1057>

### Suggested Study Plan

The master's in AI program is spread over 2 years. The courses are distributed over semesters S1, S2, S3 and S4. Following the ECTS standards, 1 ECTS accounts for a workload of 25 hours. Following the USJ standards, 1 ECTS accounts for a workload of 25 hours as follows: 7.5 contact hours and 17.5 of homework.

#### Semester 1

Code	Course Name	Credits
020IA2ES4	Artificial Intelligence	4
048DSTGM1	Graph Theory and Operations Research	4
020IAMAM1	Mathematics for AI & Machine Learning	4
020IANLM1	Natural Language Processing	4
020OPAIM1	Optimization for AI	4
020IAOOM1	Programming for AI & Machine Learning	6
020IASTM1	Statistics for AI & Machine Learning	4
	<b>Total</b>	<b>30</b>

#### Semester 2

Code	Course Name	Credits
020IACVM2	AI in Computer Vision	4
020IAFIM2	AI in Financial Technology	4
020IAROM2	AI in Robotics	4
020IAGTM2	Game Theory	4
020IADMM2	Foundations of Decision Modeling	5
020MLRES4	Machine Learning	4
020IAPCM2	Parallel Computing	5
	<b>Total</b>	<b>30</b>

#### Semester 3

Code	Course Name	Credits
020IARBM3	AI-Based Control Systems	4
020IABMM3	AI for Business and Marketing	6
020IACSM3	AI in Cybersecurity	4
020BDFRM3	Big Data Frameworks	4
020GAIES5	Generative AI	4
020IALPM3	Legal, Policy, and Ethical Considerations for Data Scientists and AI	4
020IAIDM3	Software Engineering for AI	4
	<b>Total</b>	<b>30</b>

#### Semester 4

Code	Course Name	Credits
020IAINM4	Master's Thesis	30

## Course description

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### **020IA2ES4 Artificial Intelligence - 4 Cr.**

This course aims to study artificially intelligent agents. It portrays several methods of implementing these agents: from simple reflex agents to utility-based agents as well as learning agents. We first cover greedy and A\* search, the implementation of games through the minimax and expectimax algorithms, Markov Decision Processes (MDP), and Reinforcement Learning (RL). We then introduce Machine Learning (ML) algorithms with some applications.

### **048DSTGM1 Graph Theory and Operations Research - 4 Cr.**

This teaching unit introduces students to the graph theory and operational research as modeling and decision-making tools for the data scientist. Therefore, students will learn to make a mathematical and computer representation of graphs, apply the algorithms for traversing the graphs, calculate the shortest path, maximize a flow problem, analyse complex networks, use the NetworkX Python library, use Markov chains to solve real-world problems, understand the Simplex algorithm and linear programming, use numerical tools for solving optimization problems.

### **020IAMAM1 Mathematics for AI & Machine Learning - 4 Cr.**

This course is designed to enhance students' mathematical skills, which are essential for other courses in this major. We start with the basics, including scalars, vectors, matrices, and tensors, and then progress to more advanced topics such as the Hadamard product, dot product, and various matrix types including identity, diagonal, symmetric, orthonormal, orthogonal, and inverse matrices. The course also covers solving linear equations,  $L^p$  and  $L^\infty$  norms, the Frobenius norm, eigen decomposition, diagonalization, singular value decomposition (SVD), the Moore-Penrose pseudoinverse, derivatives, gradients, the chain rule, local and absolute maxima and minima, Lagrange multipliers, and Taylor's Formula. Finally, students are requested to do a project demonstrating how these mathematical concepts can be applied in AI and machine learning.

### **020IANLM1 Natural Language Processing - 4 Cr.**

This course aims to dive into the fascinating world of Natural Language Processing (NLP), a cutting-edge field of Artificial Intelligence (AI) that empowers machines to understand, interpret, and generate human language. The course offers a comprehensive exploration of NLP, equipping students with the skills to leverage language technologies in various applications and industries. From another hand, with the rapid advancement in digital technologies and an explosion of research publications, NLP is becoming increasingly pivotal. This course is designed for individuals eager to harness the power of NLP in their careers or research endeavors. Whether Audiences are aiming to enhance customer interactions, analyze sentiment, or detect anomalies, this course will provide them with a competitive edge in today's data-driven world.

### **020OPAIM1 Optimization for AI - 4 Cr.**

This course delves into the mathematical optimization techniques essential for developing and refining machine learning algorithms and AI applications. Focusing on theoretical foundations, this course explores deep neural network initialization, gradient descent techniques, automatic differentiation and backpropagation, and adaptive learning rate algorithms such as Adam and RMSProp. Additionally, it covers principal component analysis (PCA), density estimation algorithms, and support vector machines (SVM). Students will learn to solve unconstrained and constrained optimization problems, apply these methods to neural networks, and enhance model performance. The course provides a comprehensive understanding of optimization's role in AI, equipping students with the theoretical knowledge to tackle complex challenges in various AI domains.

### **020IAOOM1 Programming for AI & Machine Learning - 6 Cr.**

The main purpose of this course is to give students the necessary tools for the development of advanced level programs by using the concept of objects in their programs. This program focuses on the fundamental building blocks you will need to learn to become an AI practitioner. Specifically, students will learn programming skills, and essential math for building an AI architecture. They will even dive into neural networks and deep learning.

### **020IASTM1 Statistics for AI & Machine Learning - 4 Cr.**

This course provides a basic high-level introduction to the mathematics and statistics that underpin many of the modern machine learning and AI algorithms. The course will cover two broad areas of statistics: inference and prediction. The inference portion introduces statistical concepts to understand populations and test hypotheses (e.g., A/B tests, p-values), while the prediction section covers algorithms from linear regression to more advanced topics like random forests and cross-validation. Real-world examples are drawn from healthcare, genetics, marketing, and manufacturing.

### **020IACVM2 AI in Computer Vision - 4 Cr.**

This course aims to study the image processing techniques: filtering morphology edge detection and segmentation. Then we apply artificially intelligent technique to detect features in images aiming to detect an image in a scene. Then we pass to the camera to see the calibration and the computer vision. Lab on MATLAB or/and python will be done to explain all AI methodologies. We will finish by the processing of images using Convolutional neural networks.

**020IAFIM2 AI in Financial Technology - 4 Cr.**

Technology is playing an increasingly dominant role in the financial service industry. It is changing how existing players operate and it is creating new ways to deliver core services like saving, investing, borrowing, and transacting. The aim of this course is to develop machine learning and AI techniques to provide solutions in the finance industry, with a focus on credit risk assessment, decision-making, and an introduction to algorithmic trading.

**020IAROM2 AI in Robotics - 4 Cr.**

This course covers the fundamental concepts of game theory and strategic thinking; normal form games; Nash equilibrium; strategies (dominated, pareto-optimal, mixed, max-min, min-max); extensive form games (with perfect/imperfect information); repeated games.

**020IAGTM2 Game Theory - 4 Cr.**

This course covers the fundamental concepts of game theory and strategic thinking; normal form games; Nash equilibrium; strategies (dominated, pareto-optimal, mixed, max-min, min-max); extensive form games (with perfect/imperfect information); repeated games.

**020IADMM2 Foundations of Decision Modeling - 5 Cr.**

Preferences are present and pervasive in many situations involving human interaction and decisions. Preferences are explicitly or implicitly expressed in numerous applications and relevant decisions should be made based on these preferences. This course aims at introducing preference models for multicriteria decisions. It covers concepts and methods for preference modeling and multicriteria decision making, convex optimization as a decision tool, decision under uncertainty, decision trees, expected utility theory and its applications, Markov decision processes and their application.

**020MLRES4 Machine Learning - 4 Cr.**

Machine learning (ML) is a subfield of Artificial intelligence. It is the science of making the machine learn by examples. The goal of ML is to make a computer that can learn from examples autonomously. The main research topics in ML include: Computer Vision (CV) and Natural Language Processing (NLP) and precision medicine for personalized treatments. The main goal of this course is to acquire a basic understanding of ML algorithms as well as hands-on ML engineering experience with regards to its application to realistic datasets through Python implementations that make use of state-of-the-art libraries such as Scikit-learn, Tensorflow and Keras.

**020IAPCM2 Parallel Computing - 5 Cr.**

Parallel architectures – Parallel Computing – Concurrency and Threads – Parallelism in Python & OpenMP – Message Passing Interface (MPI) using mpi4py – Heterogeneous programming and GPUs with CUDA and Python.

**020IARBM3 AI-Based Control Systems - 4 Cr.**

In this course, two intelligent techniques for data processing drawn from complex and imprecise environment are presented and studied. Fuzzy Logic theory is based on the empirical aspect of the human reasoning, and is used in the manipulation of imperfect, imprecise or approximate knowledge. It allows the modeling and processing of very complex systems in which, for example, human factors are present. Theory and applications concerning fuzzy logic exist for more than fifty years. They cover several fields such as artificial intelligence, identification and control of dynamic systems, automatic decision-making in complex systems, and fault diagnosis in industrial processes. On the other hand, Artificial Neural Networks are based on the biological aspect of the human brain. They are currently widely applied in various sectors such as telecommunication systems, automation, robotics, image processing and recognition, artificial intelligence, medicine and economics.

**020IABMM3 AI for Business and Marketing - 6 Cr.**

This course explores the integration of artificial intelligence tools and techniques in business and modern marketing practices. Students will delve into the utilization of AI algorithms, machine learning models, and data analytics to optimize marketing strategies across various digital channels and business decision-making. Through real-world applications and hands-on experience, students will learn to personalize content, enhance customer engagement, and drive ROI through targeted advertising and dynamic pricing. The course emphasizes ethical considerations and responsible AI usage, empowering business to leverage technology effectively while maintaining integrity and trust.

**020IACSM3 AI in Cybersecurity - 4 Cr.**

This course provides a comprehensive overview of the intersection between artificial intelligence (AI) and cybersecurity. We will explore the fundamental principles of AI, its applications in both offensive and defensive cyber operations, and the potential risks associated with AI in the cybersecurity landscape.

**020BDFRM3 Big Data Frameworks - 4 Cr.**

This course introduces students to distributed computing paradigms and big data processing techniques. It focuses on data parallel processing using MapReduce and Apache Spark. Students will gain hands-on experience in managing and analyzing large-scale datasets in distributed environments.

### **020GAIES5 Generative AI - 4 Cr.**

This course aims to immerse students in the transformative field of Generative AI, a groundbreaking area of Artificial Intelligence focused on creating content, models, and solutions that mimic human-like creativity and intelligence. The course offers a comprehensive introduction to generative models, equipping you with the knowledge and skills to harness the power of AI to generate text, images and more. Generative AI is at the forefront of technological innovation, enabling new forms of creativity and automation. This course is designed for professionals, researchers, and enthusiasts eager to explore the cutting-edge of AI and its potential to revolutionize various domains. This course covers the principles, methodologies, and applications of generative models, equipping students with the knowledge and skills to utilize these technologies in various domains of technology.

### **020IALPM3 Legal, Policy, and Ethical Considerations for Data Scientists and AI - 4 Cr.**

The purpose of this course is to give the audience, a general understanding of regulations on AI (existing and under development): the principles, standards and policies adopted by the different regulators when issuing such rules, how these are applied and how they will evolve. Throughout the course we will be addressing the general legal provisions and framework which accompanying the different regulations while focusing on the applicability of such regulations (within the relevant jurisdictions and abroad), the need for standardization processes (namely through international forums such as the UN and the OECD), the effectiveness of such regulations and the importance of ethics in the “AI world” from legal and compliance perspectives.

### **020IAIDM3 Software Engineering for AI - 4 Cr.**

The Software Engineering for AI course provides a comprehensive exploration of software engineering principles tailored for AI applications. It covers the entire software development lifecycle (SDLC) for AI projects, including requirements engineering, design patterns for machine learning applications, and software design for AI systems. The course delves into development tools and techniques essential for AI software development, and emphasizes machine learning operations (MLOps) such as model training and deployment pipelines, model monitoring and performance evaluation, version control and management of machine learning models, and responsible AI practices focusing on bias, fairness, and explainability.

### **020IAINM4 Master’s Thesis - 30 Cr.**

During the 4th semester, students must complete a professional project in a company or research work in a laboratory for a period of 4 months on a topic related to AI.

A student has the choice between:

- A professional thesis project in a company lasting 3 to 4 months, in a company on a theme related to AI, concluded by writing and defending a professional report.
- A research thesis topic lasting 3 to 4 months in a laboratory recognized by the scientific committee, concluded by writing and defending a research thesis.

The professional thesis project can take place in companies in Lebanon or abroad. The scientific responsibility for the project is provided jointly by the company and an instructor from USJ or a partner university. This project, for a minimum of one semester, aims to develop all the skills necessary for an AI specialist:

- Bibliographical search.
- Study of the state of the art.
- Proposal and implementation of solutions.

The research thesis can place in laboratories either in Lebanon or abroad. Scientific responsibility for this research is provided by the research professor(s) who supervise(s) them.

This work, of a minimum duration of one semester, aims to develop the necessary skills to carry out a decent research:

- Bibliographical search
- Critical analysis of the state of the art.
- Proposals and implementations of solutions.
- Impact and perspectives of the master thesis.

For both the project and the research thesis, a report and a public defense are required.

Students who have validated the courses of semesters 1, 2 and 3 are authorized to submit the report and defend it.

The report should include both theoretical and technical content.

The evaluation of the thesis is based on three elements:

- Evaluation of the trainee's scientific initiative.
- Evaluation of the written report.
- Evaluation of the oral defense.