MASTER IN ARTIFICIAL INTELLIGENCE

Main Language of Instruction:
French ○ English ☑ Arabic ○

Campus Where The Program Is Offered: CST

OBJECTIVES

The Master 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. Graduates will acquire expertise in a wide range of AI-related fields such as 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's 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 center, leading to the writing and defense of a thesis. Graduates will benefit from 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)

1. Acquire and apply advanced knowledge appropriate to the discipline
- Acquire theoretical and practical concepts appropriate to the discipline
- 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
- Identify and evaluate key challenges in the field
- Solve critical issues by using advanced mathematics and sciences
- Exhibit depth of knowledge in specialized areas

3. Apply new and diversified theoretical and experimental methods as appropriate to the discipline
- Demonstrate the ability to learn and apply new methods and technologies
- Utilize advanced analytical tools and techniques to solve complex issues in the field
- Integrate new technologies into existing systems to improve performance

4. Communicate, at an advanced level, in oral and written form
- Prepare clear, concise, and well-organized written reports on complex topics
- Deliver effective oral communications, demonstrating mastery of the subject matter

ADMISSION REQUIREMENTS

Admission of students is based on their file and an interview might be required.

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

To be authorized to submit application files, students must meet one of the following requirements:
- Hold a Bachelor in Computer and Communications Engineering, Computer Science, or Telecommunications;
- Hold an equivalent degree recognized by USJ.

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

To be authorized to submit application files, students must meet one of the following requirements:
- Hold *a Bachelor of Engineering in Computer and Communications Engineering or being a CCE student at ESIB and have earned at least 120 credits in the Engineering Cycle.*
- *Hold a Master in Computer Science, Computer and Communications, or Informatics.*
- *Hold* an equivalent degree recognized by USJ.

The documents required for the application file are specified in the common admission file specific for the Saint Joseph University of Beirut.
Submitted files will be examined by the Scientific Committee of the Faculty of Engineering and Architecture, which will establish the list of admitted candidates. For each application, the Committee will decide which courses are validated based on the program and the student's previous results. Selected candidates may be interviewed before their final admission. The application file is downloadable from the Saint Joseph University of Beirut's website (https://usj.edu.lb/esib/diplome.php?diplome=1057) and must be submitted at the School of Engineering of Beirut (ESIB) at USJ.

COURSES/CREDITS GRANTED BY EQUIVALENCE

Engineers with degrees in computer engineering and/or communications, holders of a Master's degree in computer science or information technology, fifth-year CCE students at ESIB, and holders of an equivalent diploma can validate, by equivalence, up to 60 credits of the program. Upon the approval of the Director of the Department of Doctoral Studies, the jury will determine, for each student admitted directly to M3, the courses and modules to be validated based on their background and prior results. The jury will define the student's path in the Master's program, which may include additional prerequisite courses. Validation of previously completed programs is subject to approval by the USJ Equivalence Commission.

PROGRAM REQUIREMENTS

Required Courses (120 credits)
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.), Machine Learning Operations (4 Cr.), Master Thesis (30 Cr.).

SUGGESTED STUDY PLAN

Semester 1

Code	Course Name	Credits
020IAAIM1	Artificial Intelligence	4
020IAGOM2	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
	Total	**30**

Semester 2

Code	Course Name	Credits
020IACVM2	AI in Computer Vision	4
020IAFIM2	AI in Financial Technology	4
020IAROM2	AI in Robotics	4
020IAGAM2	Game Theory	4
020IADMM2	Foundations of Decision Modeling	5

020IAMLM2	Machine Learning	4
020IAPCM2	Parallel Computing	5
	Total	**30**

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	Machine Learning Operations	4
	Total	**30**

Semester 4

Code	Course Name	Credits
020IAINM4	Master Thesis	30
	Total	**30**

COURSE DESCRIPTION

Semester S1 (30 credits)

020IAAIM1 Artificial Intelligence 4 Cr.

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

020IAGOM2 Graph Theory and Operations Research 4 Cr.

This course introduces students to 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. It starts with the basics, including scalars, vectors, matrices, and tensors, and then progresses 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^∞ 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 will deliver a project demonstrating how these mathematical concepts can be applied in AI and machine learning.

020IANLM1 Natural Language Processing 4 Cr.

This course explores Natural Language Processing (NLP), a field of Artificial Intelligence (AI) that enables machines to understand, interpret, and generate human language. It provides a comprehensive overview of NLP, equipping students with skills to apply language technologies in various applications and industries. The course also addresses the growing importance of NLP amid rapid digital advancements and research expansion. Students will learn to use NLP for tasks such as enhancing customer interactions, analyzing sentiment, and detecting anomalies, gaining a competitive edge in data-driven environments.

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.

This course equips students with the necessary tools for the development of advanced level programs by using object-oriented programming. This program focuses on the fundamental building blocks students will need to become AI practitioners. 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. It covers 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.

Semester S2 (30 credits)

020IACVM2 AI in Computer Vision 4 Cr.

This course covers image processing techniques, including filtering, morphology, edge detection, and segmentation. It teaches students to apply artificial intelligence methods to detect features in images and recognize objects within a scene. The course also addresses camera calibration and computer vision concepts. Labs using MATLAB and/or Python demonstrate AI methodologies, and the course concludes with image processing using convolutional neural networks.

020IAFIM2 AI in Financial Technology 4 Cr.

This course explores the role of technology in the financial services industry and its impact on operations and service delivery, including saving, investing, borrowing, and transacting. It focuses on developing machine learning and AI techniques to provide solutions in finance, emphasizing credit risk assessment, decision-making, and an introduction to algorithmic trading.

020IAROM2 AI in Robotics 4 Cr.

This course explores the integration of artificial intelligence techniques into robotics, enabling robots to perceive, reason, plan and interact with the environment intelligently. The course covers fundamental concepts, methodologies and applications in the field, with an emphasis on real-world implementation.

020IAGAM2 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.

This course introduces preference models for multicriteria decision making. It covers concepts and methods for preference modeling, convex optimization as a decision tool, decision under uncertainty, decision trees, expected utility theory and its applications, and Markov decision processes with practical applications.

020IAMLM2 Machine Learning 4 Cr.

This course covers machine learning (ML), a subfield of artificial intelligence focused on enabling computers to learn from examples autonomously. It addresses key research areas, including Computer Vision (CV), Natural Language Processing (NLP), and precision medicine for personalized treatments. The course provides a basic understanding of ML algorithms and hands-on ML engineering experience through Python implementations using state-of-the-art libraries such as Scikit-learn, TensorFlow, and Keras.

020IAPCM2 Parallel Computing 5 Cr.

This course covers the following: 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.

Semester S3 (30 credits)

020IARBM3 AI-based Control Systems 4 Cr.

This course presents and studies two intelligent techniques for data processing in complex and imprecise environments. It covers fuzzy logic, which models and processes imperfect, imprecise, or approximate knowledge, allowing the handling of complex systems involving human factors. Applications of fuzzy logic span artificial intelligence, dynamic system control, automatic decision-making, and fault diagnosis in industrial processes. The course also covers artificial neural networks, inspired by the human brain, with applications in telecommunications, automation, robotics, image processing and recognition, AI, 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 businesses 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. It explores 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 students 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.

This course provides a general understanding of AI regulations, including existing rules and those under development. It covers principles, standards, and policies adopted by regulators, their application, and expected evolution. The course examines legal provisions and frameworks accompanying these regulations, focusing on applicability within relevant jurisdictions and internationally, the role of standardization through forums like the UN and OECD, regulatory effectiveness, and the importance of ethics in AI from legal and compliance perspectives.

020IAIDM3 Machine Learning Operations 4 Cr.

This 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.

Semester S4 (30 crédits)

020IAINM4 Master Thesis 30 Cr.

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

- They must choose between:
  - A professional project in a company lasting 3 to 4 months, on a theme related to AI, concluded with writing and defending a professional report.
  - A research topic lasting 3 to 4 months in a laboratory recognized by the Scientific Committee, concluded with writing and defending a research paper.
- The projects 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, of a minimum of one semester, aims to develop all the skills necessary for an AI specialist:
  - Bibliographic search.
  - Study of the state of the art.
  - Proposal and implementation of solutions.
- The research takes place in a laboratory either in Lebanon or abroad. Scientific responsibility for this research is provided by the research professor(s) who supervise students. This work, of a minimum duration of one semester, aims to develop the necessary skills to carry out research work:
  - Bibliographic search.
  - Critical analysis of the state of the art.
  - Proposals and implementations of solutions.
  - Proposals and dissemination for thesis work.
- The project or research work is the subject of a report or a written dissertation and a public defense. Students who have validated the theoretical courses of semesters 1, 2, and 3 are authorized to submit the project report and, if applicable, the research paper.

The thesis or report includes a bibliographic part and a technical part. The evaluation of the project or research work considers three elements:

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