# Master in Computer science

**Programme mnemonic**
MA-INFO
> Focus *Professional* : M-INFOS

**Studies level**
Master 120 credits

**Learning language**
english

**Schedule**
office hours

**Studies category / subcategory**
Sciences and technics / Sciences

**Campus**
Plaine

## Programme objectives

The Master program aims to train students to become high-level computer scientists in the IT industry and/or research. The program wishes to form a new generation of IT executives, managers and researchers who are autonomous, aware of their role in society, and can efficiently acquire new knowledge all along with their career. In particular the students are expected to

# be able to gather information and acquire new knowledge autonomously and with scientific rigour, and adopt a critical attitude in this process.

# master the main mathematical and formal tools needed in computer science.

# be able to read technical literature in English and engage in a technical conversation in English

# master the main concepts and skills related to programming, programming languages, algorithms, software engineering, operating systems, computational intelligence and theoretical results in computer science.

# be able to design—alone or within a group—a computer application of significant complexity, efficiently using the tools of software engineering.

## Programme's added value

The Master program offers a mandatory common core of 30 ECTS and five optional modules covering major advanced topics in Computer Science:

# Software and critical systems,

# Computational intelligence,

# Optimization,

# Algorithms,

# Web and information systems.

Other optional courses are made available by other related MA programs (e.g. in Applied Sciences).

The advanced classes benefit from the excellence of the research conducted in the Computer Science Department of the Faculty of Science, as witnessed by the publications record and the several awarded prizes, and collaboration with researchers from ULB Applied Sciences and VUB (Vrije Universiteit Brussel).

In the second year of the Master, students can take a three-month full-time internship in either a private company or a research centre.

The program is completed by a MA thesis intended to prepare the student to enter the labour market or to pursue a research career (e.g. by enrolling in doctoral studies).

## Teaching methods

Courses are typically structured in two parts: a theoretical part, in which concepts and theories are developed, and a more practical part, where those concepts are applied to examples and case studies. Courses are complemented by medium- to large-size projects, often inspired by recent and challenging applications of Computer Science.

Teaching assistants are always present during the many practical sessions to offer help and are often available to answer student questions.

Computer rooms, equipped with state-of-the-art hardware and operating systems, are available to students for practicals and projects.

## Succeed in your studies

**Choose**

The information and guidance counsellors at the InfOR-études [https://www.ulb.be/en/studies-info-desk-1] service will help you choose your studies throughout the year.

**Succeed**

Take part in preparatory courses [https://www.ulb.be/en/studies-info-desk-1] or get help to succeed [https://www.ulb.be/en/studies-info-desk-1] , before or during your studies.

**Get help**

Apply for financial aid, look for accommodation or a student job, get support [https://www.ulb.be/fr/aides-services-et-accompagnement/aid-services-and-support-1] for your specific needs.

## International/Openness

Students can participate in international exchange programs (e.g. Erasmus) to attend classes abroad during one semester. The Computer Science department has several ongoing agreements with other departments around Europe and North America. More specifically, students who follow the specialisation on Optimization may complete one or two semesters at the Université de Nantes (France) and earn a joint degree from the two institutions.

## Job opportunities

Graduates find work in various sectors: banks, insurance companies, software industry, consulting, hospitals, schools, universities, national and international administrations. They can work as project leaders, IT specialists, data scientists, network architects, security experts, teachers, or researchers. Some conduct their businesses, and others are high-level executives in administrations.

In summary, the main occupations that the program provides access to are:

\# IT Project Manager

\# IT Consultant

\# IT Manager

\# Computer security architect

\# Teacher

\# Data scientist

\# Researcher

**Contacts**

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☎ +32 2 650 56 14

☁ https://sciences.ulb.be/departement-d-informatique

**Jury President**
Jean-François RASKIN

**Jury Secretary**
Joël GOOSSENS

# Master in Computer science
## Focus Professional

The master programme includes three main types of courses: computer science lectures, an introduction to research through the writing of a Master's dissertation, and courses intended to prepare students to enter the job market.

The programme is designed for students who have general skills in computer science, which they can have acquired during the Bachelor in Computer Science at ULB:

> they are able to gather information and acquire new knowledge autonomously and with scientific rigour, and are able to adopt a critical attitude in this process.

> they master the main mathematical and formal tools needed in computer science.

> they can read technical literature in English and engage in a technical conversation in English, as most of the courses in the programme are taught in English (with a few exceptions for electives).

> They master the main concepts and skills related to programming, programming languages, algorithms, software engineering, operating systems, and fundamental theoretical results in computer science.

> they are able to design—alone or within a group—a computer application of significant complexity, efficiently using the tools of software engineering.

Students who have not acquired the appropriate background during their Bachelor may, in some cases, have the opportunity to compensate for deficiencies with a tailored curriculum.

## Bloc 1 | M-INFOS | MA-INFO

## Cours obligatoires

ELEC-H473 **Microprocessor architecture** | Dragomir MILOJEVIC (Coordinator)
5 credits [lecture: 24h, practical work: 36h]   second term   English

INFO-F403 **Introduction to language theory and compiling** | Gilles GEERAERTS (Coordinator)
5 credits [lecture: 24h, tutorial classes: 24h, project: 30h]   first term   English

INFO-F404 **Real-Time Operating Systems** | Joël GOOSSENS (Coordinator)
5 credits [lecture: 24h, tutorial classes: 12h, project: 30h]   first term   English

INFO-F405 **Introduction to cryptography** | Christophe PETIT (Coordinator) and Gilles VAN ASSCHE
5 credits [lecture: 24h, tutorial classes: 24h, project: 30h]   first term   English

INFO-F408 **Computability and complexity** | Jean-François RASKIN (Coordinator)
5 credits [lecture: 36h, tutorial classes: 12h, practical work: 12h]   first term   English

MEMO-F403 **Preparatory work for the master thesis** | Maarten JANSEN (Coordinator)
5 credits [personal assignments: 60h]   second term   English

## Options 1

Option - 2 modules complets dans la liste des modules 1.1 à 1.5 à choisir au cours des deux blocs.

*A total of 30 credits chosen from the following*

### Module 1.1. Software and critical systems

INFO-F410
(optional)   **Embedded systems design** | Jean-François RASKIN (Coordinator)
5 credits [lecture: 12h, tutorial classes: 12h, project: 60h]   second term   English

INFO-F412
(optional)   **Formal verification of computer systems** | Jean-François RASKIN (Coordinator)
5 credits [lecture: 36h, tutorial classes: 12h]   second term   English

INFO-F514
(optional)

**Protocols, cryptanalysis and mathematical cryptology** | Olivier MARKOWITCH (Coordinator), Liran LERMAN and Christophe PETIT

⊙ 5 credits [lecture: 24h]   📅 second term   💬 English

## Module 1.2. Computational Intelligence

INFO-F409
(optional)

**Learning dynamics** | Tom LENAERTS (Coordinator)

⊙ 5 credits [lecture: 24h, project: 60h]   📅 first term   💬 English

INFO-F422
(optional)

**Statistical foundations of machine learning** | Gianluca BONTEMPI (Coordinator)

⊙ 5 credits [lecture: 24h, tutorial classes: 12h, project: 60h]   📅 second term   💬 English

INFO-H410
(optional)

**Techniques of artificial intelligence** | Hugues BERSINI (Coordinator)

⊙ 5 credits [lecture: 24h, tutorial classes: 12h]   📅 second term   💬 English

## Module 1.3. Optimization

INFO-F424
(optional)

**Combinatorial optimization** | Bernard FORTZ (Coordinator) and RENAUD CHICOISNE

⊙ 5 credits [lecture: 24h, tutorial classes: 12h, practical work: 12h, project: 30h]   📅 second term   💬 English

INFO-F524
(optional)

**Continuous optimization** | Bernard FORTZ (Coordinator) and Dimitrios PAPADIMITRIOU

⊙ 5 credits [lecture: 24h, project: 60h]   📅 second term   💬 English

INFO-H413
(optional)

**Heuristic optimisation** | Thomas,T STUTZLE (Coordinator)

⊙ 5 credits [lecture: 24h, tutorial classes: 12h, practical work: 24h]   📅 second term   💬 English

## Module 1.4. Algorithms

INFO-F413
(optional)

**Data structures and algorithms** | Jean CARDINAL (Coordinator)

⊙ 5 credits [lecture: 24h, tutorial classes: 12h, project: 60h]   📅 first term   💬 English

INFO-F420
(optional)

**Computational geometry** | Stefan LANGERMAN F. SWARZBERG (Coordinator)

⊙ 5 credits [lecture: 24h, tutorial classes: 12h, project: 60h]   📅 first term   💬 English

INFO-F521
(optional)

**Graph theory** | Gwenaël JORET (Coordinator)

⊙ 5 credits [lecture: 24h, tutorial classes: 12h, project: 60h]   📅 first term   💬 English

## Module 1.5. Web and information systems

INFO-H415
(optional)

**Advanced databases** | Esteban ZIMANYI (Coordinator)

⊙ 5 credits [lecture: 24h, tutorial classes: 24h, practical work: 12h]   📅 first term   💬 English

INFO-H417
(optional)

**Database systems architecture** | Mahmoud SAKR (Coordinator)

⊙ 5 credits [lecture: 24h, tutorial classes: 12h, practical work: 24h]   📅 first term   💬 English

INFO-H515
(optional)

**Big Data: Distributed Data Management and Scalable Analytics** | Dimitrios SACHARIDIS (Coordinator) and Gianluca BONTEMPI

⊙ 5 credits [lecture: 24h, tutorial classes: 12h, project: 24h]   📅 second term   💬 English

**Master in Computer science**
Focus Professional

**Bloc 2** | M-INFOS | MA-INFO

## Cours obligatoires

INFO-F530 — Computer science seminar | Tom LENAERTS (Coordinator), Jérôme De Boeck, Bernard FORTZ, John IACONO and Olivier MARKOWITCH
5 credits [seminars: 36h, project: 60h]   first and second terms   English

MEMO-F524 — Masters thesis | Jean-François RASKIN (Coordinator)
20 credits [mfe/tfe: 240h]   first and second terms

*An alternative chosen from the two following*

## Options 1

35 ECTS à choisir dans les options 1 dont minimum 2 modules complets au cours des 2 blocs. (60 crédits sur l'ensemble du cycle)

*Up to 60 credits chosen from the following*

### Module 1.1 Software and critical systems

INFO-F410
(optional) — Embedded systems design | Jean-François RASKIN (Coordinator)
5 credits [lecture: 12h, tutorial classes: 12h, project: 60h]   second term   English

INFO-F412
(optional) — Formal verification of computer systems | Jean-François RASKIN (Coordinator)
5 credits [lecture: 36h, tutorial classes: 12h]   second term   English

INFO-F514
(optional) — Protocols, cryptanalysis and mathematical cryptology | Olivier MARKOWITCH (Coordinator), Liran LERMAN and Christophe PETIT
5 credits [lecture: 24h]   second term   English

### Module 1.2 Computational Intelligence

INFO-F409
(optional) — Learning dynamics | Tom LENAERTS (Coordinator)
5 credits [lecture: 24h, project: 60h]   first term   English

INFO-F422
(optional) — Statistical foundations of machine learning | Gianluca BONTEMPI (Coordinator)
5 credits [lecture: 24h, tutorial classes: 12h, project: 60h]   second term   English

INFO-H410
(optional) — Techniques of artificial intelligence | Hugues BERSINI (Coordinator)
5 credits [lecture: 24h, tutorial classes: 12h]   second term   English

### Module 1.3 Optimization

INFO-F424
(optional) — Combinatorial optimization | Bernard FORTZ (Coordinator) and RENAUD CHICOISNE
5 credits [lecture: 24h, tutorial classes: 12h, practical work: 12h, project: 30h]   second term   English

INFO-F524
(optional) — Continuous optimization | Bernard FORTZ (Coordinator) and Dimitrios PAPADIMITRIOU
5 credits [lecture: 24h, project: 60h]   second term   English

INFO-H413
(optional) — Heuristic optimisation | Thomas,T STUTZLE (Coordinator)
5 credits [lecture: 24h, tutorial classes: 12h, practical work: 24h]   second term   English

## Module 1.4 Algorithms

**INFO-F413**
(optional)

Data structures and algorithms | Jean CARDINAL (Coordinator)
5 credits [lecture: 24h, tutorial classes: 12h, project: 60h]   first term   English

**INFO-F420**
(optional)

Computational geometry | Stefan LANGERMAN F. SWARZBERG (Coordinator)
5 credits [lecture: 24h, tutorial classes: 12h, project: 60h]   first term   English

**INFO-F521**
(optional)

Graph theory | Gwenaël JORET (Coordinator)
5 credits [lecture: 24h, tutorial classes: 12h, project: 60h]   first term   English

## Module 1.5 Web and Information Systems

**INFO-H415**
(optional)

Advanced databases | Esteban ZIMANYI (Coordinator)
5 credits [lecture: 24h, tutorial classes: 24h, practical work: 12h]   first term   English

**INFO-H417**
(optional)

Database systems architecture | Mahmoud SAKR (Coordinator)
5 credits [lecture: 24h, tutorial classes: 12h, practical work: 24h]   first term   English

**INFO-H515**
(optional)

Big Data: Distributed Data Management and Scalable Analytics | Dimitrios SACHARIDIS (Coordinator) and Gianluca BONTEMPI
5 credits [lecture: 24h, tutorial classes: 12h, project: 24h]   second term   English

## Module 2.1 Software and critical systems

**INFO-Y082**
(optional)

Distributed and mobile programming paradigms | Elisa GONZALEZ BOIX
6 credits [lecture: 26h, tutorial classes: 26h, project: 30h]   first term   English

**INFO-Y085**
(optional)

Functional programming | Wolfgang DE MEUTER (Coordinator)
6 credits [lecture: 26h, tutorial classes: 26h]   second term   English

**INFO-Y099**
(optional)

Multicore programming | SWALLENS Janwillem
6 credits [lecture: 26h, tutorial classes: 26h]   second term   English

**INFO-Y1001**
(optional)

Practical Parallel Program | Jan LEMEIRE
3 credits [lecture: 12h, project: 30h]   first term   French

**INFO-Y1002**
(optional)

GPU computing | Jan LEMEIRE
5 credits [lecture: 12h, project: 45h]   second term   French

**INFO-Y110**
(optional)

Higher Order Programming | Nicolas JENS
6 credits [lecture: 26h, tutorial classes: 26h]   first term

## Module 2.2 Computational Intelligence

**INFO-F439**
(optional)

Advanced Methods in Bioinformatics | Matthieu DEFRANCE (Coordinator) and Wim VRANKEN
5 credits [lecture: 24h, project: 90h]   second term   English

**INFO-H414**
(optional)

Swarm Intelligence | Marco DORIGO (Coordinator) and Mauro BIRATTARI
5 credits [lecture: 12h, practical work: 48h]   second term   English

**INFO-H515**
(optional)

Big Data: Distributed Data Management and Scalable Analytics | Dimitrios SACHARIDIS (Coordinator) and Gianluca BONTEMPI
5 credits [lecture: 24h, tutorial classes: 12h, project: 24h]   second term   English

**INFO-Y004**
(optional)

Natural language processing | Paul VAN EECKE
6 credits [lecture: 26h, tutorial classes: 26h]   first term   English

**INFO-Y087**
(optional)

Declarative programming | WIGGINS Geraint and VAN EECKE Paul
6 credits [lecture: 26h, tutorial classes: 26h]   second term   English

## Module 2.3 Optimization

## Module 2.4 Algorithms

**INFO-F440**
(optional)

Algorithms for big data | John IACONO (Coordinator)
5 credits [lecture: 24h, tutorial classes: 12h, project: 60h]   second term   English

INFO-H514
(optional)

Quantum information and computation | Nicolas CERF (Coordinator), Ognyan Oreshkov and Jérémie ROLAND

⏲ 5 credits [lecture: 24h, tutorial classes: 24h]   📅 first term   💬 English

## Module 2.5 Web and Information Systems

INFO-H419
(optional)

Data warehouses | Esteban ZIMANYI (Coordinator)

⏲ 5 credits [lecture: 24h, tutorial classes: 24h, practical work: 12h]   📅 first term   💬 English

INFO-H420
(optional)

Management of Data Science and Business Workflows | Dimitrios SACHARIDIS (Coordinator)

⏲ 5 credits [lecture: 24h, tutorial classes: 36h]   📅 first term   💬 English

INFO-H509
(optional)

Geo-Spatial and web technologies | Mahmoud SAKR (Coordinator)

⏲ 5 credits [lecture: 24h, tutorial classes: 12h, practical work: 24h]   📅 second term   💬 English

INFO-Y528
(optional)

Information visualisation

⏲ 6 credits [lecture: 26h, tutorial classes: 26h]   📅 second term   💬 English

## Module 2.6 Internship

GEST-S483
(optional)

Digital and IT Governance | Georges ATAYA (Coordinator)

⏲ 5 credits [lecture: 24h]   📅 second term   💬 English

TRAN-F501
(optional)

Internship | Gianluca BONTEMPI (Coordinator) and Maarten JANSEN

⏲ 15 credits [project: 200h]   📅 first term   💬 English

*or*

# Variante Master ORO - Université de Nantes

Students attending one or two semesters at the University of Nantes in the framework of the double diploma register to the 30 or 60 ECTS corresponding to their stay in Nantes in Block 2.

INFO-Y515
(optional)

Large Scale Optimisation

⏲ 3 credits [lecture: 13h, tutorial classes: 13h]   📅 academic year

INFO-Y516
(optional)

Discrete Constraint Programming

⏲ 3 credits [lecture: 13h, tutorial classes: 13h]   📅 academic year

INFO-Y517
(optional)

Global Optimization

⏲ 3 credits [lecture: 13h, tutorial classes: 13h]   📅 academic year

INFO-Y518
(optional)

Black-box Optimization

⏲ 3 credits [lecture: 13h, tutorial classes: 13h]   📅 academic year

INFO-Y519
(optional)

Multi-Objective Optimization

⏲ 3 credits [lecture: 13h, tutorial classes: 13h]   📅 academic year

INFO-Y520
(optional)

Cloud Artifcial Intelligence Services

⏲ 3 credits [lecture: 13h, tutorial classes: 13h]   📅 academic year   💬 English

INFO-Y521
(optional)

Transportation and Logistics

⏲ 3 credits [lecture: 13h, tutorial classes: 13h]   📅 academic year

INFO-Y522
(optional)

Planning and Scheduling

⏲ 3 credits [lecture: 13h, tutorial classes: 13h]   📅 academic year

INFO-Y523
(optional)

Bioinfomatics

⏲ 3 credits [lecture: 13h, tutorial classes: 13h]   📅 academic year

INFO-Y524
(optional)

OR Special Topic II

⏲ 2 credits [lecture: 13h, tutorial classes: 13h]   📅 academic year

INFO-Y525
(optional)

Conferences

⏲ 1 credit [tutorial classes: 26h]   📅 academic year

INFO-Y526
(optional)
**Master Thesis (track research)**
🕐 20 credits 📅 academic year

INFO-Y527
(optional)
**Internship (track application)**
🕐 10 credits 📅 academic year