MASTER IN SENSOR PHYSICS AND INSTRUMENTATION

Concentrations
Medical Radiophysics
Sensors and Instrumentation

Main Language of Instruction:
French ☑ English ○ Arabic ○

Campus Where The Program Is Offered: CST

OBJECTIVES

M1 (S1-S2): Common core for the 2 concentrations: Medical Radiophysics and Sensors and Instrumentation.
The 1st year of the Master in Sensor Physics and Instrumentation offers a high-level, general training in physics, enabling students to pursue their studies in the various M2 concentrations, as well as in most national and international M2 physics programs.
M2 (S3-S4): Medical Radiophysics concentration.
The Medical Radiophysics concentration aims to:
- Train scientists specialized in medical radiophysics
- Prepare students for careers as radiophysicists
- Prepare students for PhD studies in the field of medical physics.

M2 (S3-S4): Sensors and Instrumentation concentration (double degree with *Université de Bretagne occidentale - France*).
The Sensors and Instrumentation concentration aims to:
- Train scientists to work in companies using sensor systems, or to develop sensors or sensor systems.
- Train scientists for industrial R&D departments developing or using intelligent sensors, acquisition systems, data modeling and analysis, and artificial intelligence in imaging.
- Train students for PhD studies in all fields of applied physics.

PROGRAM LEARNING OUTCOMES (COMPETENCIES)

- Manage instrumental equipment for companies using sensor systems or networks, in industrial and hospital environments
- Guarantee the quality and safety of the medical use of ionizing radiation
- Optimize medical applications of ionizing radiation in therapy and diagnostics in nuclear medicine and imaging departments in public and private hospitals.
- Join a PhD program in the fields of applied physics and/or medical physics
- Conduct research and development studies in industrial and hospital environments
- Manage a technological project
- Solve complex physics problems.

ADMISSION REQUIREMENTS

Students must hold a Bachelor in Physics or an engineering degree (deemed equivalent by the USJ Equivalence Commission) from USJ or any other institution.

COURSES/CREDITS GRANTED BY EQUIVALENCE

Law and Legislation (2 Cr.). Industrial Computing (2 Cr.). Atomic and Molecular Physics (6 Cr.). Solid State and Semiconductor Physics (6 Cr.). Nuclear Physics (6 Cr.). Advanced Quantum Physics (2 Cr.). Data Processing and Analysis (6 Cr.). Entrepreneurship (4 Cr.). Condensed Matter Physics (4 Cr.). Medical Physics (6 Cr.). Experimental Design (2 Cr.). Professional Development (4 Cr.). Project Management (4 Cr.). Data Science in Physics (6 Cr.). Optics and Materials (6 Cr.).

PROGRAM REQUIREMENTS

Required Courses – Common Core (84 credits), Institution's Elective Courses – Common Core (6 credits), Required Courses – Concentration: Medical Radiophysics (30 credits), Required Courses – Concentration: Sensors and Instrumentation (18 credits), Institution's Elective Courses – Concentration: Sensors and Instrumentation (12 credits).

Required Courses – Common Core (84 Cr.)
Law and Legislation (2 Cr.). Entrepreneurship (4 Cr.). Industrial Computing (2 Cr.). Atomic and Molecular Physics (6 Cr.). Condensed Matter Physics (4 Cr.). Solid State and Semiconductor Physics (6 Cr.). Medical Physics (6 Cr.). Nuclear Physics (6 Cr.). Advanced Quantum Physics (2 Cr.). Experimental Design (2 Cr.). Professional Development (4 Cr.). Project Management (4 Cr.). End-of-Study Project (30 Cr.). Data Processing and Analysis (6 Cr.).

Institution's Elective Courses – Common Core (6 Cr.), to be chosen from the list below:
Data Science in Physics (6 Cr.). Optics and Materials (6 Cr.).

Required Courses – Concentration: Medical Radiophysics (30 Cr.)
Anatomy and Physiology (4 Cr.). Physics of Radiotherapy (8 Cr.). Physics of Ionizing Radiation (4 Cr.). Radiobiology (2 Cr.). Radiation Protection and Detection Systems (6 Cr.). Medical Imaging Techniques (6 Cr.).

Required Courses – Concentration: Sensors and Instrumentation (18 Cr.)
Signal Acquisition, Conditioning and Processing (6 Cr.). Digital Electronics and Real-Time Measurement Systems (6 Cr.). General Principles of Sensors (6 Cr.).

Institution's Elective courses – Concentration: Sensors and Instrumentation (12 Cr.), to be chosen from the list below:
Sensors in Environment and Health (6 Cr.). Data Science in Physics (6 Cr.). Waves and Matter (6 Cr.). Optics and Materials (6 Cr.). Radioprotection and Detection Systems (6 Cr.). Imaging Techniques in Medicine (6 Cr.). Instrumentation for Physics (6 Cr.).

SUGGESTED STUDY PLAN

Semester 1

Code	Course Name	Credits
	Required Courses – Common Core	
048DRLTM1	Law and Legislation	2
048IICPM1	Industrial Computing	2
048ATCPM1	Atomic and Molecular Physics	6
048SCOPM1	Solid State and Semiconductor Physics	6
048NUCPM1	Nuclear Physics	6
048QACPM1	Advanced Quantum Physics	2
048TADTM1	Data Processing and Analysis	6
	Total	**30**

Semester 2

Code	Course Name	Credits
	Required Courses – Common Core	
048ETPTM2	Entrepreneurship	4
048PMCPM2	Condensed Matter Physics	4
048MECPM2	Medical Physics	6

048PEXCM2	Experimental Design	2
048PVPTM2	Professional Development	4
048PRMTM2	Project Management	4
048DSCPM2 **or** 048OPCPM2	Institution's Elective Courses Data Science in Physics **or** Optics and Materials	6
	Total	**30**

Semester 3

Code	Course Name	Credits
	Required Courses – Concentration: Medical Radiophysics	
048APCPM3	Anatomy and Physiology	4
048PRDPM3	Physics of Radiotherapy	8
048PRIPM3	Physics of Ionizing Radiation	4
048RDBPM3	Radiobiology	2
048RPRPM3	Radiation Protection and Detection Systems	6
048TIMPM3	Medical Imaging Techniques	6
	Total	**30**
	Required Courses – Concentration: Sensors and Instrumentation	
048ASCPM3	Signal Acquisition, Conditioning and Processing	6
048SMCPM3	Digital Electronics and Real-Time Measurement Systems	6
048PGCPM3	General Principles of Sensors	6
048INCPM3 or 048CSCPM3 **or** 048OMCPM3 or 048RPRPM3 or 048TIMPM3	Institution's Elective Courses Instrumentation for Physics or Sensors in Environment and Health **or** Waves and Matter or Radiation Protection and Detection Systems or Medical Imaging Techniques	6
	Total	**30**

Semester 4

Code	Course Name	Credits
048PFETM4	End-of-Study Project	30
	Total	**30**

COURSE DESCRIPTION

048DRLTM1 Law and Legislation 2 Cr.

This course is divided into two parts: The first part aims to define intellectual property, which encompasses all exclusive rights granted for intellectual creations: legal rights to an idea, invention, or creation in industrial, scientific, literary, and artistic domains. The objective is to present the interests and advantages of such a concept before detailing the procedures for registering inventions or products.
The second part aims to provide students with the set of rules governing interactions with citizens. It covers consumer law, business law, social law, labor law, as well as environmental law. These rules are codified, and students must be able to identify texts related to each domain to navigate them. It includes:

1. International environmental law and its application in Lebanon
2. Labor law
3. Social security law
4. Commercial law
5. Company law and industrial law.

048IICPM1 Industrial Computing 2 Cr.

This course presents LabVIEW (Laboratory Virtual Instrument Engineering Workbench) as a platform for designing measurement and control systems using a graphical development environment from National Instruments. It covers applications in data acquisition, instrument control, and industrial automation.

048ATCPM1 Atomic and Molecular Physics 6 Cr.

This course presents atomic physics as a branch of physics exploring phenomena and applications of classical and quantum physics at macroscopic, microscopic, and atomic scales. It covers atomic structure, physical and chemical processes, microscopic properties, and interactions with electromagnetic radiation. The course also addresses atomic physics in terms of atoms, molecular physics, interatomic processes, and both fundamental and applied applications.

048SCOPM1 Solid State and Semiconductor Physics 6 Cr.

This course presents solid state physics as the study of classical and quantum phenomena at macroscopic, microscopic, and atomic scales. It covers the properties of crystalline solids, electronic states in solids, and properties of crystalline semiconductors, highlighting the field's significant impact on technological development.

048NUCPM1 Nuclear Physics 6 Cr.

This course presents nuclear physics as a discipline with applications in astrophysics, medicine, life sciences, and engineering, developed rapidly through military and energy research. It covers the properties and structure of the nucleus, nucleon binding energy, nuclear transformations and emissions, and nuclear models.

048QACPM1 Advanced Quantum Physics 2 Cr.

This course presents quantum mechanics as a framework for explaining atomic structure, molecules, solids, nuclear structure, nuclear reactions, and elementary particle physics. It also introduces quantum computing as an active area of research. The course covers key approximation methods and their applications in contemporary mechanics.

048TADTM1 Data Processing and Analysis 6 Cr.

This course is divided into three main parts.

- The first part, "Metrology", introduces students to metrology, the science of measurement, providing them with the information they need to manage and control measurement processes and equipment.
- The second part, "Statistics", introduces students to the importance of statistics in data analysis, study planning and understanding the scientific literature.
- The third part, "Multivariate Analysis", is designed to equip students with the skills needed to use statistical tools to extract information and create new knowledge from complex databases obtained by analytical or

other means. It involves simultaneously analyzing a set of explanatory variables and constructing multivariate models to describe, compare, classify and predict the characteristics of samples of individuals. Multivariate analysis is widely used in all fields of science, engineering, pharmacology, medicine, economics and sociology.

048ETPTM2 Entrepreneurship 4 Cr.

This course introduces students to entrepreneurship and provides them with the key tools any entrepreneur needs to succeed, including notions of accounting and finance. The first part of the course describes the role of entrepreneurs, analyzes the action of generating wealth and/or employment through starting or taking over a business, explains the different forms of entrepreneurship, addresses the concepts of creativity, innovation and market benefit, and supports the idea of risk-taking for the entrepreneur.
The second part provides an overview of the conceptual and regulatory framework underlying financial accounting, as well as an understanding of the content and structure of financial statements so as to be able to read them and understand what financial statements can and cannot reveal about a commercial or industrial institution. It also covers the different types of financial accounting information encountered in managerial life, providing a basic guide to cover all the important accounting concepts and managerial reporting tools that support appropriate managerial decision-making.
The final section aims to familiarize students with finance concepts and explain the basics of financial markets. Examples will help to apply the theories discussed in practice.

048PMCPM2 Condensed Matter Physics 4 Cr.

This course complements the "Solid State and Semiconductor Physics" course, with the main aim of showing the effects of phenomena observed at the atomic scale on the macroscopic properties of materials. Initially, the dielectric response function is discussed and its influence on the optical properties of materials explained. Next, the magnetic and electrical properties of materials are theoretically detailed at both atomic and macroscopic scales. Examples of industrial applications are inserted into the course to enable students to assess the usefulness of the theoretical models studied.

048MECPM2 Medical Physics 6 Cr.

This course presents medical physics as an interdisciplinary science covering the applications of physics in medicine, including diagnostics, therapy, ionizing radiation dosimetry, instrumentation, and radiation protection. It addresses opportunities in clinical, industrial, and research fields.
The course focuses on the physics of ionizing radiation, including its interactions with living matter and detection, with examples from dosimetry, radiotherapy, and handling radioactive sources. It also covers medical imaging, explaining the physical principles underlying imaging with ionizing radiation and the techniques currently in use. Students will learn to apply these principles and techniques in medical and research contexts.

048PEXCM2 Experimental Design 2 Cr.

This course introduces the methodology of experimental designs, which are robust measurement methods validated by means of multiple linear regressions, analysis of variance (ANOVA), and so on. Several designs are studied: complete two-level factorial designs, designs for second-degree models: complete three-level factorial designs, star-centered composite designs, faces-centered composite designs, etc. The study strategy enables trials to be organized in such a way as to minimize study costs. Result processing enables the detection of significant effects and interactions among operating parameters. It also enables empirical modeling, the creation of response surfaces, and the search for an optimum. This methodology is very useful in the food, biological and chemical industries. The designs of experiments for formulation are also covered: unconstrained mixture design (type I), mixture design with constraints on lower limits (type II), mixture design with constraints on lower and upper limits with deformation of the parameter variation domain (type III). Statgraphics software is used to create the experimental designs.

048PVPTM2 Professional Development 4 Cr.

This course presents industrial visits as a way to observe the stages of industrial production, including production management, control, and final product testing. It also covers principles of analytical method development.

In the M1 PCI program, the course takes the form of an internship under the supervision of an internship director. Students will write a detailed report on their work and present it to a jury of Master's instructors and industry representatives.
The rules governing the presentation and grading of the report are as follows:

1. Oral presentation time is limited to a maximum of 20 min (plus 20 min for questions and 15 min for jury deliberation).
2. The final defense grade takes into account:
   - Oral presentation, including answers to questions
   - Internship supervisor's report
   - The form and content of the report, as assessed by the reviewers.

048PRMTM2 Project Management 4 Cr.

This course is an introduction to the fundamentals of project management: knowledge, techniques, methods and practices. It is fully aligned with the world's best-known international standards, those of the Project Management Institute, based on the two dimensions of project management, the 5-phase project life cycle: initiate, plan, execute, control and close, and the 10 knowledge categories.

048DSCPM2 Data Science in Physics 6 Cr.

This course prepares students for the analysis of scientific data. The types of data encountered in the field of physics are now well known, and the corresponding analysis tools are also available. Thus, this course serves as a basis for students to become aware of data analysis methods specific to the field of applied research, covering data considered manageable on a simple personal computer and massive data requiring more specific processing algorithms.

048OPCPM2 Optics and Materials 6 Cr.

This course presents optics as the branch of physics studying light, electromagnetic radiation, vision, and systems that use or emit light. It covers the main principles of radiation-matter interactions and introduces the different levels of these interactions.

048ASCPM3 Signal Acquisition, Conditioning and Processing 6 Cr.

The course is divided into two parts: a brief presentation of the various components of an acquisition chain and their limitations (acquisition-conditioning part), followed by a more detailed part on the study of signals and systems in both the time and frequency domains. The course is completed by 2 to 3 MATLAB-based practical sessions to familiarize students with sampling problems and the calculation of LTI system outputs.

048SMCPM3 Digital Electronics and Real-Time Measurement Systems 6 Cr.

This course presents digital electronics as the study of electronic systems with states limited to a finite set of possibilities, ensuring stable and reliable behavior. It contrasts digital electronics with analog electronics, which operates on continuously varying quantities.
The course also introduces embedded systems as autonomous electronic and computer systems, often real-time, designed for specific applications. It covers low-power microprocessors or microcontrollers, with software partially or fully programmed into hardware. Students will study examples such as beverage vending machines, automobiles, medical equipment, cameras, aircraft, cell phones, and PDAs to understand the design and function of embedded systems.

048PGCPM3 General Principles of Sensors 6 Cr.

This course provides a clear, didactic overview of all the factors involved in choosing and using a sensor in industry. After a presentation of the different families of sensors (active or passive, integrated, composite, etc.), the course proposes, for the various physical quantities to be measured (light, temperature, position, deformation, etc.), the types of sensors best suited to the measurement conditions imposed. In particular, it presents: their physical operating principles; their metrological characteristics: sensitivity, linearity, speed, fidelity, accuracy; the procedures for their implementation; the electrical assemblies known as "conditioners" (bridges, amplifiers, converters, etc.) associated with them to optimize their performance.

048CSCPM3 Sensors in Environment and Health 6 Cr.

This course is divided into two parts: one relating to the environment and the other to health. In the first part, the aim is to understand the physical phenomena linked to the natural variability of the specific characteristics of terrestrial and marine environments, to design all the methods linked to the real-time monitoring of environmental quality and the operation of measuring stations, and finally, to acquire physical knowledge related to atmospheric remote sensing. The second part covers sensor applications in the health sector, particularly in hospitals and medical analysis laboratories.

048INCPM3 Instrumentation for Physics 6 Cr.

This course covers advanced laser technologies, tools for microstructural and magnetic characterization of materials and instrumentation in the field of radio frequencies.

048OMCPM3 Waves and Matter 6 Cr.

This course explains different laser and RF/HF investigation techniques and their applications in the biomedical and environmental fields. The course also tackles nanoscale coupling phenomena through experiments (CPCE).

048APCPM3 Anatomy and Physiology 4 Cr.

The course includes a series of lectures covering the anatomical and physiological description of the main organs of the human body.

048PRDPM3 Physics of Radiotherapy 8 Cr.

This course provides a good grounding in the physics of ionizing radiation in the medical environment. It aims to apply the theory of measurements and calculations of absorbed doses following irradiation with photons and electrons.

048PRIPM3 Physics of Ionizing Radiation 4 Cr.

The course details the processes by which particles interact with matter, taking into account the different types of particles and the different incident energy ranges. This course is necessary to understand the mechanisms of radiation interaction and to extrapolate them to medical applications.

048RDBPM3 Radiobiology 2 Cr.

This course is an essential prerequisite for any other course concerning the application of ionizing radiation in medicine, such as radiotherapy. The content mainly focuses on effects at the molecular scale, since any observable macroscopic effect is only a manifestation of processes taking place at the nanoscale. In this way, the lecture-based content provides students with the knowledge base they need to continue their training in physics applied to medicine.

048RPRPM3 Radiation Protection and Detection Systems 6 Cr.

The course provides a general overview of all aspects of radiation protection for patients, the public, staff and the environment in hospitals.

048TIMPM3 Medical Imaging Techniques 6 Cr.

The course consists of an understanding of the physical basis, technology and operation of the imaging techniques most commonly used in medicine.

048PFETM4 End-of-Study Project 30 Cr.

This course represents the end-of-study project for students, during which they will carry out an internship in industry or a research laboratory lasting between 4 and 7 months. At the end of the internship, students will write a detailed report on the personal work carried out and present it to a jury made up of Master's instructors and representatives from the professional world.
The rules governing the presentation and grading of the report are as follows:

1. Oral presentation time is limited to 20 min maximum (plus 20 min for questions and 15 min for jury deliberation).
2. The final defense grade takes into account:
   - Oral presentation, including answers to questions
   - The internship director's report
   - The form and content of the report, as assessed by the reviewers.