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 (RPM) and Sensors and Instrumentation (CI). 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 objectives of the RPM concentration are to:
- Train scientists specialized in medical radiophysics
- Prepare students for careers as radiophysicists
- Prepare students for a PhD dissertation.

M2 (S3-S4): Sensors and Instrumentation concentration (double degree with *Université de Bretagne occidentale*). The CI 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 radiotherapy, nuclear medicine and imaging departments in public and private hospitals.
- Join a PhD program in a field of applied physics
- Conduct research and development studies in industrial and hospital settings
- Manage a technological project
- Solve complex physics problems.

ADMISSION REQUIREMENTS

Students with a Bachelor in Physics or an engineering degree from USJ or elsewhere (deemed equivalent by the USJ Equivalence Commission).

COURSES/CREDITS GRANTED BY EQUIVALENCE

048DRLTM1 - Law and Legislation (2 Cr.). 048IICPM1 - Industrial Computing (2 Cr.). 048ATCPM1 - Atomic and Molecular Physics (6 Cr.). 048SCOPM1 - Solid State and Semiconductor Physics (6 Cr.). 048NUCPM1 - Nuclear Physics (6 Cr.). 048QACPM1 - Advanced Quantum Physics (2 Cr.). 048TADTM1 - Data Processing and Analysis (6 Cr.). 048ETPTM2 - Entrepreneurship (6 Cr.). 048PMCPM2 - Condensed Matter Physics (4 Cr.). 048MECPM2 - Medical Physics (6 Cr.). 048PEXCM2 - Experimental Design (2 Cr.). 048PVPTM2 - Professional Development (4 Cr.). 048PRMTM2 - Project Management (4 Cr.). 048DSCPM2 - Data Science in Physics (4 Cr.). 048OPCPM2 - Optics and Materials (4 Cr.).

PROGRAM REQUIREMENTS

RPM concentration:
Required Courses (116 credits)
Anatomy and Physiology (4 Cr.). Law and Legislation (2 Cr.). Entrepreneurship (6 Cr.). Industrial Computing (2 Cr.). Atomic and Molecular Physics (6 Cr.). Condensed Matter Physics (4 Cr.). Physics of Radiotherapy (8 Cr.). Physics of Ionizing Radiation (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.). Radiobiology (2 Cr.). Radiation Protection and Detection Systems (6 Cr.). Medical Imaging Techniques (6 Cr.). Data Processing and Analysis (6 Cr.).
Institution's Elective courses (4 credits)
Data Science in Physics (4 cr.). Optics and Materials (4 Cr.).

CI concentration:
Required Courses (110 credits)
Signal Acquisition, Conditioning and Processing (6 Cr.). Law and Legislation (2 Cr.). Digital Electronics and Real-Time Measurement Systems (6 Cr.). Entrepreneurship (6 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.). General Principles of Sensors (6 Cr.). Project Management (4 Cr.). End-of-Study Project (30 Cr.). Data Processing and Analysis (6 Cr.). P

Institution's Elective courses (10 credits)
Sensors in Environment and Health (6 Cr.). Data Science in Physics (4 Cr.). Waves and Matter (6 Cr.). Optics and Materials (4 Cr.). Physics of Radiotherapy (8 Cr.). Physics of Ionizing Radiation (4 Cr.). Radiobiology (2 Cr.). Radioprotection and Detection Systems (6 Cr.). Imaging Techniques in Medicine (6 Cr.).

SUGGESTED STUDY PLAN

Semester 1

Code	Course Name	Credits
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
048ETPTM2	Entrepreneurship	6
048PMCPM	Condensed Matter Physics	4
048MECPM2	Medical Physics	6
048PEXCM2	Experimental Design	2

048PVPTM2	Professional Development	4
048PRMTM2	Project Management	4
048DSCPM2 048OPCPM2	Data Science in Physics Optics and Materials	4
	Total	**30**

Semester 3: RPM Concentration

Code	Course Name	Credits
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**

Semester 3: CI Concentration

Code	Course Name	Credits
048ASCPM3	Signal Acquisition, Conditioning and Processing	6
048SMCPM3	Digital Electronics and Real-Time Measurement Systems	6
048PGCPM3	General Principles of Sensors	6
048INCPM3	Instrumentation for Physics	6
048CSCPM3 048OMCPM3	Sensors in Environment and Health Waves and Matter	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.

The first part of this course 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 of this course 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 will include:

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.

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is the heart of a platform for the design of measurement and control systems, based on a graphical development environment from National Instruments. It is mainly used for data acquisition measurement, instrument control and industrial automation.

048ATCPM1 Atomic and Molecular Physics 6 Cr.

Atomic physics is a branch of physics that offers a wide range of phenomena and applications of classical and quantum physics at the macroscopic, microscopic and atomic scales. The aim of this course is to study the structure of atoms, physical and chemical processes and properties at the microscopic scale, and interactions with electromagnetic radiation. In addition, the course covers the various aspects of atomic physics, namely the physics of the atom, the physics of atoms (molecule physics and interatomic processes) and the fundamental and applied applications of atomic physics.

048SCOPM1 Solid State and Semiconductor Physics 6 Cr.

Solid state physics is the branch of physics that offers a wide range of phenomena and applications of classical and quantum physics on macroscopic, microscopic and atomic scales. For several decades, considerable research and development efforts have been devoted to this field, with a direct and undeniable impact on society's technological development. Topics covered include: properties of crystalline solids, electronic states in solids, properties of crystalline semiconductors, etc.

048NUCPM1 Nuclear Physics 6 Cr.

Nuclear physics is a discipline that today covers a vast and varied field of research: astrophysics, medicine, life sciences, engineering sciences and more. Its development has been extremely rapid thanks to its military and energy applications, which have provided researchers with considerable experimental resources. This course covers the basic principles of nuclear physics and its main applications. The course covers the properties of the nucleus, its structure and the binding energy of nucleons, nuclear transformations and emissions, and nuclear models.

048QACPM1 Advanced Quantum Physics 2 Cr.

Quantum mechanics, designed to explain atomic structure, was rapidly and successfully applied to the study of molecules and solids. It has proved highly fertile for the study of the structure of the nucleus and nuclear reactions, as well as for the physics of elementary particles. Quantum computing is currently the subject of intense research activity. This course should enable students to pursue specialized studies in one of the many fields requiring a good grounding in quantum mechanics. It also aims to familiarize them with the most important approximation methods in the many applications of quantum mechanics to contemporary mechanics.

048TADTM1 Data Processing and Analysis 6 Cr.

The "Data Processing and Analysis" 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 6 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 creating wealth and/or employment through the creation or takeover of 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 from accounting 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.

Medical physics is an interdisciplinary science that covers all applications of physics in medicine, both for diagnostic and therapeutic aspects, and more particularly in the fields of ionizing radiation dosimetry, instrumentation, radiation protection, etc. This branch of physics, with its wide range of topics, offers opportunities in clinical, industrial and research fields.
A major part of the course is devoted to the physics of ionizing radiation, in particular its interactions with living matter and its detection. The examples presented in the course are chosen from the various fields of application with which physicists are likely to be confronted, e.g. relative and absolute dosimetry of linear gas pedals, radiotherapy treatments, handling of radioactive sources, etc.
The second part of the course covers medical imaging, including all the physical phenomena underlying medical imaging using ionizing radiation, as well as the principle and application of the techniques currently in use.

048PEXCM2 Experimental Design 2 Cr.

This course is an approach to the study of 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 between operating parameters. It also enables empirical modeling, obtaining response surfaces and searching 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.

Industrial visits are designed to show the different stages of a given industrial production. They explain how the production unit works, how production is managed and controlled during the various stages, and how the final product is tested to ensure conformity. This course also covers the principles of analytical method development. In the M1 PCI program, this course consists of an internship under the supervision of an internship director. 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 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 4 Cr.

The aim of this course is to prepare 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 4 Cr.

Optics is the branch of physics that deals with light and its properties, electromagnetic radiation, vision and systems that use or emit light. The course covers the main principles of interaction between radiation and matter, and introduces the different levels of this interaction.

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.

Digital electronics is a scientific field concerned with electronic systems whose states run through a finite set of possibilities. Determinism in changes of state (transitions) enables systems to behave stably and reliably. In particular, it eliminates parasites and other deformations.
This type of electronics is opposed to analog electronics, which deals with electronic systems operating on continuously varying quantities (voltage, current, load).
An embedded system is defined as an autonomous electronic and computer system, often real-time, which is specially designed for a particular type of application, unlike personal computers or workstations, which are more general-purpose.
Embedded systems generally use low-power microprocessors or microcontrollers, with the software part partially or entirely programmed into the hardware, usually in ROM, EPROM, etc.
Beverage vending machines, automobiles, medical equipment, cameras, aircraft, cell phones and PDAs are all examples of systems that house 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.

In this course, students learn 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.

The aim of this course is to provide 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.