

**COURSE DATA****DATA SUBJECT**

Code: 46991
Name: Smart materials with advanced functionalities
Cycle: Master's Degree
ECTS Credits: 8
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
2278 - Master in Advanced Materials	Facultat de Química	1	Second quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
2278 - Master in Advanced Materials	Materiales inteligentes con funcionalidades avanzadas	COMPULSORY

COORDINATION**SUMMARY**

This course will be taught, together with the module MA5, intensively during 3 weeks in May and each year at a different university. The course will be taught in English.

This course aims to train students in the most relevant aspects of advanced characterization and modeling of materials and devices. Likewise, the main concepts of materials design with advanced functionality (particularly materials that respond to external stimuli) will be explained, serving as a basis for developing applications primarily in four specific areas: Information and Communications Technologies, Health, Mobility, and Habitat and Environment.

PREVIOUS KNOWLEDGE**RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE**

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

Previous knowledge of chemistry, physics or materials science as taught in the degrees indicated in the recommended entry profile to the master's degree is required. Previous knowledge of materials science as taught in the Introduction Module (MA1) is required.

**COMPETENCES / LEARNING OUTCOMES****DESCRIPTION OF CONTENTS****U4.1. Advanced Characterization and Modeling of Materials/Devices**

- Nanoscale characterization of materials under operating conditions/in situ/in operand integrated into electronic/electrochemical devices.
- Multi-scale simulation of material/device properties using high-performance computational techniques. Correlation of the chemical composition and nano/microstructure of the material with its properties.

U4.2. Functional Materials for ICTs

- Materials design for electronics and molecular spintronics. Integration of molecular nanostructures into (opto)electronic devices (OFETs, OLEDs, spin valves, etc.). Study of their properties. Basic concepts of coherent electron transport in molecular nanodevices. Experimental techniques for measuring quantum transport and theoretical modeling. Basic concepts of spin transport in molecular spintronic devices.
- Design of molecules and functional materials for quantum information technologies. Basic concepts: quantum bits, quantum gates, quantum devices based on spin quantum bits. Advanced characterization techniques.
- Design of functional materials with memristive properties for neuromorphic computing.

U4.3. Materials for biomedical applications

- Design of functional molecules and nanomaterials that respond to exogenous stimuli (light, temperature, magnetic or electric fields, etc.) or endogenous stimuli (pH, presence of small molecules or biomolecules, presence of radicals, reducing medium, etc.).
- Incorporation into organic or inorganic nanosystems for biomedical applications: controlled release, implants, artificial organs, biomaterials, materials for advanced therapies, antimicrobial and antifungal materials, or materials with applications in in vitro molecular diagnostics or imaging (probes, biomarkers, biosensors, etc.).

U4.4. Multifunctional materials and devices for sustainable mobility, habitat, and the environment

- Mobility: design and integration of smart multifunctional materials into structural health monitoring systems for components; design of multifunctional products related to energy management for mobility (battery architecture, hydrogen tanks, vehicle-integrated solar cells); design of new lightweight multifunctional materials for transportation.
- Habitat and environment: ceramic products with new functionalities (electronic, biological, etc.); design of porous materials for the environment, catalysis, and electronics; generation of smart structures for energy applications; new smart materials for energy management in buildings; polymers with advanced functionalities (biopolymers with active, sensory, and intelligent behavior and controlled biodegradation; polymers based on dynamic chemistry); sustainability in processes and products through the recycling and recovery of both industrial and natural waste.

WORKLOAD

**PRESENCIAL ACTIVITIES**

Activity	Hours
Theory	48,00
Classroom practices	33,00
Total hours	81,00

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	0,00
Independent study and work	0,00
Preparation of lessons	9,00
Preparation for assessment activities	42,00
Resolution of case studies	68,00
Total hours	119,00

TEACHING METHODOLOGY

The main training activities and face-to-face teaching methodologies will be the **theoretical classes** and the **seminars**. During the seminars, the theoretical contents of the modules will be worked on in a practical way. Among the methodologies used in the seminars are the discussion of articles, debate and guided discussion, discussion of practical cases and resolution of problems and questions and visits to laboratories and scientific facilities of the university where the classes are held that year.

These training activities will be carried out intensively each year at a different university, which will be attended by students and teaching staff from all the universities. Through this mobility between the participating universities, students will be able to benefit from the knowledge of various renowned professors and researchers distributed throughout the territory. Given that these modules deal with advanced and specific concepts, the inter-university nature of the master's degree means that students will be able to count on expert lecturers in each of the subjects covered at all the universities.

After the theory classes, students will have to solve a series of **questions and problems** posed by each of the lecturers of these modules, through this work, students will develop and assimilate the concepts studied during the face-to-face classes.

The resolution of these questions involves a great deal of individual work by the students, as well as the pooling with the rest of the students, and they will also have the participation of the teaching staff to resolve any doubts. During the seminar hours, guidelines will have been given for the resolution of the questions and initial doubts will have been resolved. In the weeks following the intensive classes, group **tutoring sessions** will be carried out in online, synchronous and interactive mode. During these sessions, guidance will be offered to students and doubts will be resolved about the questionnaire, once students have started working on it, as well as about the preparation of the exam.

Students will also be able to contact the professors individually at any time to resolve any doubts they may have.

This combination encourages direct interaction between students and teachers as well as the autonomous work of students, which allows them to deepen their knowledge of the topics covered and apply what they have learnt autonomously.



EVALUATION

SE3- Active participation in face-to-face activities: 10%

SE1- Written exam on basic subject content: 90%

SE3- Active participation in face-to-face activities: Continuous assessment of students based on their involvement and commitment to the teaching-learning process. Their participation in debates and discussions, as well as in solving simple problems related to the module content, will be taken into account. Students' level of interest, understanding and analytical ability of the content taught, as well as their ability to formulate relevant questions and comments and respond to questions and problems posed by the professor will be assessed.

SE1- Written exam on basic subject content: Students' achievement of the various learning outcomes will be assessed through an individual final written exam. The degree of mastery of the fundamental concepts taught during the theoretical classes and intensive seminars, as well as the students' independent work through solving questions posed by the professors, will be taken into account.

Exams may include different types of questions, such as short answers, short essays, and problem-solving, in order to assess both the knowledge acquired and the students' analytical, synthesizing, and argumentative skills.

Each student will take the exam, in person, at their university of enrollment. It will be a common exam for all participating universities, ensuring equal conditions for all students and facilitating a controlled and reliable assessment.

Attendance at training activities is mandatory. To pass the module, students must have attended all in-person training activities and regulated tutorials, except in duly justified cases.

REFERENCES