

**COURSE DATA****DATA SUBJECT****Code:** 46989**Name:** Graphene and Other Two-Dimensional Materials**Cycle:** Master's Degree**ECTS Credits:** 6**Academic year:** 2026-27**STUDY (S)**

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

SUBJECT-MATTER

| Degree | Subject-matter | Character |
|-------------------------------------|--|------------|
| 2278 - Master in Advanced Materials | Grafeno y otros materiales bidimensionales | COMPULSORY |

COORDINATION

CORONADO MIRALLES EUGENIO

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SUMMARY

This course will be taught, together with the module MA3, intensively during 3 weeks in January and each year at a different university. The course will be taught in English.

The discovery of graphene has made 2D materials one of the most important research focuses in current Materials Science. This course aims to introduce students to the study of these advanced materials, from the new physics that emerges at the 2D limit to the chemical design and controlled and scalable production of new 2D materials and heterostructures for their applications.

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

2278 - Master in Advanced Materials

Capacity for learning, responsibility and decision-making: Act autonomously in learning, make informed decisions in different contexts, issue judgements based on experimentation and analysis and transfer knowledge to new situations.

Creative and entrepreneurial skills: Propose creative and innovative solutions to complex situations or problems within the field of knowledge to respond to diverse professional and social needs.

Critically analyse, evaluate and synthesise new ideas to solve problems in complex or unfamiliar environments within broader contexts in the different areas of impact and application of materials.

Critical thinking, ethical commitment and professional responsibility: Demonstrate critical and self-critical reasoning in the field of the degree, considering aspects such as professional ethics, moral value and the social implications of the different

Design preparation methods for 2D materials, functionalised 2D materials, heterostructures and nanocomposites.

Emotional intelligence: Understand and regulate one's own emotions and those of others to interact and participate effectively and constructively in social and professional life.

Gender perspective: Know and understand, within the area of the degree, inequalities based on sex and gender in society; integrate different needs and preferences based on sex and gender into the design of solutions and problem-solving.

Have the knowledge and skills necessary to pursue future doctoral studies in the field of materials.

Identify and classify 2D materials and their derivatives.

Predict and rationalise the physical properties of 2D materials.

Relate the type of advanced material to the best methods of production, manufacturing and processing of the final device.

Social commitment and sustainability: Contribute to the design, development and implementation of solutions that respond to social demands, considering the Sustainable Development Goals as a reference.

Students from one area of knowledge (e.g. physics) should be capable of communicating and interacting scientifically with peers from other areas of knowledge (e.g. chemistry) in the analysis and resolution of common problems.

Teamwork and leadership: Collaborate effectively in work teams, taking on responsibilities and leadership roles and contributing to collective improvement and development.



Understand advanced techniques for the structural and physical characterisation of 2D materials.

Understand the main techniques for the preparation, characterisation and properties of 2D materials, van der Waals heterostructures and 2D material nanocomposites, as well as the information they provide and their limitations.

Understand the main technological applications of 2D materials and their derivatives, and be able to place them within the general context of materials science.

Understand the main types of 2D materials based on their structural characteristics and composition.

Understand the most relevant applications of 2D materials.

Understand the state of the art in 2D materials.

Understand the structure property relationship in different advanced stimuli-responsive materials and distinguish their fields of application.

Understand the top-down and bottom-up preparation techniques of 2D materials, van der Waals heterostructures and nanocomposites.

DESCRIPTION OF CONTENTS

U2.1. Introduction to 2D materials.

- Graphene: preparation techniques and general properties.
- Classification of 2D materials. Examples of materials with relevant properties.
- Top-down and bottom-up preparation techniques.
- Van der Waals heterostructures.

U2.2. Emerging physical properties at the 2D boundary

- Superconductivity and magnetism in 2D materials. Excitons in 2D materials: valleytronics. Advanced characterization techniques.
- Emergent properties in heterostructures. Twistronics.
- Control of properties in 2D materials: effect of doping; effect of stress; effect of the application of electric or magnetic fields; etc.

U2.3 Application of chemistry to the development of 2D materials.

- Chemical functionalization of 2D materials.
- Molecular approach to 2D materials.
- Fabrication and properties of hybrid heterostructures and nanocomposites based on 2D materials.

U2.4. Applications of 2D materials

- Electronic devices: field effect transistors, optoelectronic devices, spintronic devices.
- Mechanical devices: membranes and sensors.
- Electroactive 2D materials for energy storage and generation.
- Applications in medicine.

WORKLOAD

**PRESENCIAL ACTIVITIES**

| Activity | Hours |
|---------------------|--------------|
| Theory | 36,00 |
| Classroom practices | 25,00 |
| Total hours | 61,00 |

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 | 7,00 |
| Preparation for assessment activities | 32,00 |
| Resolution of case studies | 50,00 |
| Total hours | 89,00 |

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 enrolment. 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