GUÍA DOCENTE
2024 - 2025

FICHA TÉCNICA DE LA ASIGNATURA

Datos de la asignatura	
Nombre completo	Optativa Complementaria. Nanotechnology
Código	DIM-OPT-422
Título	Grado en Ingeniería Electromecánica por la Universidad Pontificia Comillas
Impartido en	Grado en Ingeniería en Tecnologías Industriales [Cuarto Curso]
Nivel	Reglada Grado Europeo
Cuatrimestre	Semestral
Créditos	3,0 ECTS
Carácter	Optativa (Grado)
Departamento / Área	Departamento de Ingeniería Mecánica
Responsable	Marcos Benedicto Córdoba
Horario	Friday 10:15-12:05
Horario de tutorías	Schedule to be agreed with the teacher
Descriptor	This subject is a fundamental course on nanotechnology

Datos del profesorado	
Profesor	
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Profesores de laboratorio	
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DATOS ESPECÍFICOS DE LA ASIGNATURA

Contextualización de la asignatura

Aportación al perfil profesional de la titulación

Nanotechnology is a convergence between several disciplines such as physics, chemistry, biology, medicine or engineering. Technology at the nanoscale is invading our lives, and the industry requires professionals with backgrounds in different knowledge domains to continue with the technological development and get to make our lives easier. This subject is a fundamental course on nanotechnology. During the lessons, the students will acquire the most important knowledges about the topic, which represent tools to deepen on their own, and keys to approximate the nanotechnology industry. On completion of this course, students should be able to:

1. understand how the basic nanosystems work;

2. understand how the properties of the matter change at the nanoscale;
3. know the main fabrication methodologies used in nanotechnology;
4. know the main characterization techniques used in nanotechnology;
5. know the main areas of application of nanotechnology;
6. report their work in a clear and precise way through talks and reports.

Prerrequisitos

There are not needed any prerequisites to course the subject. The students are expected to understand basic chemical and physical concepts, as supplied by subjects as Chemistry, Materials Science, Mechanics and Thermodynamics, an equivalent course or provide evidence of equivalent capabilities. Microsoft Word and Microsoft PowerPoint are useful for writing reports and oral presentations.

Competencias - Objetivos

Competencias

GC1: Conduct research, development and innovation in products, processes and methods.

GC2: Apply the knowledge acquired to solve problems in new or unfamiliar environments within broader and multidisciplinary contexts.

GC3: Be able to clearly and unambiguously communicate conclusions, and the knowledge and reasons that support them, to specialized and non- specialized audiences.

GC4: Acquire learning skills that will allow further study in a self-directed or autonomous way.

CE1. Basic knowledge on nanoscience and nanotechnology, and learning of new methods and theories about the behaviour of the matter within the nanoscale.

CE2. Ability to handle new concepts about how the mechanical, electronic, photonic and biological properties change within the nanoscale.

CE3. Ability to handle new concepts about the fabrication, characterization and applications of nanostructures.

CE4. Ability to design, simulate, synthesize/manufacture, and characterize nanostructures.

Resultados de Aprendizaje

At the end of the course, the students should be able to:

RA1: Know why nanostructures are important from the point of view of the nanotechnology science.

RA2: distinguish between the different physical systems, at the nanoscale, according to their size and special limitations.

RA3: know how the properties of the matter change when their dimensions are reduced to the nanoscale.

RA4: decide on the most appropriate technique to produce a certain nanostructure.

RA5: decide on the most appropriate characterization technique to evaluate a particular property in a nanoscale system.

RA6: know the main areas of application of the nanotechnology.

RA7: know the most innovative applications in the field of nanotechnology through talks and reports.

BLOQUES TEMÁTICOS Y CONTENIDOS

Contenidos – Bloques Temáticos

Unit 1: INTRODUCTION TO THE NANOWORLD

Unit 2: PHYSICS AND CHEMISTRY WHITIN THE NANOSCALE

2.1 Basics on quantum mechanics.

2.2 Chemical bonding and crystal structure.

2.3 Volumetric or 3D materials.

2.4 Spatial confinement.

Unit 3: PROPERTIES OF MATTER AT THE NANOSCALE

3.1 Mechanics and fluid mechanics.

3.2 Electronics and photonics.

3.3 Biology and medicine.

Unit 4: NANOFABRICATION

4.1 Bottom-up and top-down techniques.

4.2 Nanofabrication by replication and pattern transfer.

4.3 Nanofabrication by self-assembly.

4.4 Nanofabrication by scanning probes.

4.5 Indirect nanofabrication.

Unit 5: CHARACTERIZATION TECHNIQUES

5.1 Structural and morphological characterization

5.2 Compositional characterization

5.3 Optical and electrical characterization

5.4 Mechanical characterization techniques

Unit 6: APPLICATIONS AND ADVANCES OF THE NANOTECHNOLOGY

This unit will be developed by students, through reports and oral presentations in class, under the supervision of the teacher.

LAB SESSIONS

Lab 1. Nanofabrication. Silver nanoparticles synthesis.

Lab 2 Nanofabrication. Graphene production: mechanical and chemical processes.

Lab 3. Nanocharacterization. AFM and STM.

Lab 4. Simulation of nanostructures.

METODOLOGÍA DOCENTE

Aspectos metodológicos generales de la asignatura

Both classroom sessions and independent study are developed to imply the students within the learning activities. The contents have been developed in order to maintain student attention and facilitate the acquisition of the skills mentioned above. Student activities are key factors in the developing this course. To achieve the objectives set in the subject, the following methodology will be used:

1. Expository lessons:

The teacher will explain the concepts through presentations. The PDF versions of theses theoretical presentations will be accessible for students through the Moodlerooms platform. Students will be able to participate during the classes, asking for clarifications about the concepts presented in class, as well as asking questions about any aspect related to the subject. The subject also encourages students to take their own class notes in order to facilitate further study.

2. Lab sessions:

The lab activities will help students to better understand the theoretical concepts learned in class, considering them from a more practical point of view. Specifically, after its completion, students will be able to face the simulation, fabrication and characterization of nanostructures. The students will be divided into groups of 3-4 people, all the lab activities will be carried out as a group, in order to favour team working. At the end of every activity they will learn how to properly write a single lab protocol, skill which is extensible for any experimental discipline.

3. Projects:

At the end of the course, each lab group will choose a topic from a list provided by the teacher. Every group will prepare a report on its topic and show its work on the last day of the course, through an oral presentation. This activity will favour team working and will train students in the search, contrast, analysis and presentation of scientific information, which is also applicable for any experimental discipline.

4. Tutorials:

In order to clarify any aspect of the subject, and only when those questions have not been previously solved in class, or during the lab sessions, students will be able to request individual tutorials (with no more than 3 people at the same time), both to the lab and theory teachers, upon previous request to them by mail. This office hours will be used also by the students to be guide by the teachers during their learning process.

Metodología Presencial: Actividades

Master classes: presentation of the main concepts related to the subject including dynamic presentations, current examples of real applications related to the aforementioned concepts and explanatory videos from both educational institutions and companies.

Practical sessions: 4 practical activities will be carried out, 2 in the classroom and 2 in the lab.

Follow-up tests: 4 follow-up tests will be carried out. During these tests,students will not be able to consult any material but they will be able to talk each other. The objectives of this dynamic are to evaluate the concepts exposed during the master classes and also to promote critical thinking and collective problem solving.

Oral presentations: presentations of the group projects developed during the course,

Tutorials: small support sessions for single students or a maximum of 4 will be organised upon request from students,

Metodología No presencial: Actividades

Exercises: after each unit the teacher will provide a list of exercises related to it that students must solve in groups.

Preparation of activities and reports: students must read and understand the scripts for the activites they are going to carry out, as well as consult the additional materials provided by the teacher and submit the corresponding group report once the practice has been completed.

Project development: group development of the written document associated with the subject project and preparation of the corresponding oral presentation.

Review and internalization of acquired knowledge: review and study of the materials and concepts that will be evaluated through follow-up tests and the final exam using the materials provided by the teacher.

RESUMEN HORAS DE TRABAJO DEL ALUMNO

CLASSROOM SESSIONS

Theoretical Classes (18)

Laboratory Activities (8)

Presentations/Final Evaluation (4)

INDEPENDENT STUDY

Self-study on theory (20)

Self-work on Lab Protocols (12)

Preparation for Examinations (16)

Preparation for Presentations (16)

EVALUACIÓN Y CRITERIOS DE CALIFICACIÓN

Written assessment 60%

- Understanding of fundamental concepts.

- Presentation and written communication.

Lab assessment 20%

- Understanding of the concepts reviewed during the execution of the activity, and its application for the resolution of practical problems.

- Analysis and interpretation of results.

- Skills in the lab.

- Ability to elaborate written reports.

Project assessment 20%

- Understanding of the main concepts covered by the chosen topic.

- Ability to elaborate written reports.

- Ability to report the work in a clear and precise way through an oral presentation and communication skills.

Calificaciones

Regular assessment

The score for the ordinary final mark will be obtained by:

50% written examination (≥ 5.0),

10% follow-up examinations (homework + tests),

20% lab sessions (≥ 5.0),

20% project (≥ 5.0).

* The lack of assistance to some of the activities is a 0 in that session.

* A delay in the delivery of reports means a minimum penalty of 2 points.

Retake

The score for the extraordinary final mark will be obtained by:

80% Written examination (≥ 5.0)

10% comes from the lab assessment,

10% comes from project assessment.

Course rules

Class attendance is mandatory according to Article 93 of the General Regulations (Reglamento General) of Universidad Pontifica Comillas and Article 6 of the Academic Rules (Normas Académicas) of the ICAI-School of Engineering. Not complying with this requirement may have the following consequences:

Students who fail to attend more than 15% of the lectures may be denied the right to take the final exam during the regular assessment period.

Absence to more than 15% of the lab sessions can result in losing the right to take the final exam of the regular assessment period and the retake. Missed sessions must be made up for credit.

Students who commit an irregularity in any graded activity will receive a mark of zero in the activity and disciplinary procedure will follow (cf. Article 168 of the General Regulations (Reglamento General) of Comillas Pontifical University).

Students must obtain a minimum score of 5.00/10.00 on both the project report and presentations; a lower rating will be a fail in the subject.

PLAN DE TRABAJO Y CRONOGRAMA

Actividades	Fecha de realización	Fecha de entrega
• Reading and studying the theoretical contents in the textbooks. - Before lesson. • Study on the slides showed in class. - After lesson. • Study with additional information. - After lesson. • Project report and oral presentations. - At the end of the course. • Lab assessments. - During the course. • Follow-up examinations. - During the course. • Final examination. - At the end of the course.	01/01/2025	01/05/2025

BIBLIOGRAFÍA Y RECURSOS

Bibliografía Básica

The PDF versions of the rules of the subject, the presentations of the theoretical Units, the lab protocols, and the information about the projects, will be accessible for students through the Moodlerooms platform. The platform will also allow students to deliver reports for labs and projects.

Student class notes.

Bibliografía Complementaria

B. Rogers, S. Pennathur, J. Adams, Nanotechnology Understanding Small Systems. Third Edition, CRC Press, 2015.

Z. Cui, Nanofabrication, Principle, Capabilities and Limits. Second Edition, Springer, 2016.

S. Zhang, L. Li, A. Kumar, Materials Characterization Techniques. CRC Press, 2008.