COURSE SYLLABUS
2017-2018

GENERAL INFORMATION

Course Information	
Name	Nanotechnology
Code	DIM-OPT-432
Degree	Grado en Ingeniería Electromecánica
Year	All years
Semester	2º
ECTS credits	3 ECTS
Type	Elective
Department	Mechanical Engineering
Area	Energy/Materials
Coordinator	Juan Carlos del Real Romero

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SPECIFIC SUBJECT DATASHEET

Subject contextualization

Contribution to the professional profile of the Title

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 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:

a) To understand how basic nanosystems work;
b) To understand how the matter properties change at the nanoscale;
c) To know the main nanofabrication techniques;
d) To know the main characterization techniques used in nanotechnology;
e) To know the main areas of application of nanotechnology;
f) To report their work in a clear and precise way through talks and reports.

Prerequisites

There are not needed any prerequisites to study the subject; students are expected to have an understanding of basic chemical and physical concepts, as supplied by 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.

THEME TITLES AND CONTENTS

Theme Titles - Contents
Lectures
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 approaches. 4.2 Nanofabrication by particle beams. 4.3 Nanofabrication by replication and pattern transfer. 4.4 Nanofabrication by self-assembly. 4.5 Nanofabrication by scanning probes. 4.6 Indirect nanofabrication.
Unit 5: CHARACTERIZATION TECHNIQUES
5.1 Structural and morphological characterization. 5.2 Compositional characterization. 5.3 Optical characterization. 5.4 Mechanical characterization. 5.5 Synchrotron and accelerators as characterization facilities.
Unit 6: APPLICATIONS AND ADVANCES OF THE NANOTECHNOLOGY
This unit that will be developed by students, through oral presentations in class, under the supervision of the teacher.
Laboratory
Lab 1. Simulation of nanostructures
This practice is aimed to help students understand the importance of designing nanomaterials. Thus, this practice is intended to help students learn the use of nanomaterials design programs used most frequently in the world.
Lab 2. Nanofabrication. Silver nanoparticles synthesis.
This Lab Class is designed to familiarize students with the production of nanomaterials and to gain experience with characterization tools used in nanoscale science and engineering.
Lab 3 Nanofabrication. Graphene production: mechanical and chemical processes.
This Lab Class is designed to familiarize students with the production of nanomaterials and to gain experience with characterization tools used in nanoscale science and engineering.
Lab 4. Nanocharacterization. AFM and STM.
In this practice students will familiarize with the structural characterization one of the most important tools used in nanoscale science and engineering: scanning probe microscopy (SPM). Students will learn about the basis of work of atomic force microscopy (AFM) and scanning tunnelling microscopy (STM). The students will demonstrate the appropriate use such techniques of images processing and the information one can get from them.
Visits
During the course visits can be scheduled prior agreement with the students, the university and the centres involved. The realization of these visits will be determined by the class schedule, the academic calendar, and the availability of the centres involved. Two visits are being contemplated: 1) visit a leading research centre specialized in nanotechnology, 2) visit a particle accelerator.

Competences and Learning Outcomes

Competences

General Competences

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

GC2: Apply the acquired knowledge 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 rationale that support them– to specialist and non-specialist audiences.

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

Basic Competences

Knowledges on nanotechnology, acquiring tools to deepen on their own and keys to approximate the nanotechnology industry

Specific Competences

CE1. Knowledge on basic concepts on nanoscience and nanotechnology. Learning of new method and theories about the behaviour of the matter at the nanoscale.

CE2. Ability to handle new concepts about how the mechanical, electronic, photonic and biological properties of the matter at the nanoscale.

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

CE4. Ability to simulate, synthetize and characterize nanostructures

Learning outcomes

By the end of the course students should be able to:

RA1: know why the nanostructures are important from the standpoint of science and nanotechnology.

RA2: distinct 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 its dimensions are reduced to the nanoscale.

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

RA5: decide the most appropriate characterization technique to evaluate a particular property in a nanostructure.

RA6: know the main areas of application of nanotechnology.

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

TEACHING METHODOLOGY

Subject methodological aspects

Both classroom sessions and independent study are developed to imply the students within the learning activities. The contents are developed to keep the student attention and following the competencies acquisition by the students. Student activities are key factors to develop this course. In order to achieve the objectives set in the subject the following methodology will be used.

In-class activities

1. **Expository lessons**:

   The teacher will explain the concepts through presentations that will be accessible to students before the class. Students may participate setting out questions or any issues relating to the subject.

2. **Laboratory sessions:**

   The laboratory activities will allow students to fabricate, characterize and simulate nanostructures. They will have to prepare the lab protocols.

3. **Talks:**

   The students, divided into groups of no more than 3 people, will conduct an oral presentation on different topics chosen by them from a list provided by the teacher.

4. **Tutorials:**
   They will be individual or for groups of no more than 3 people in order to answer questions after working through the different units, and guide students in their learning process.

Out-of-class activities

1. **Self-study on the concepts presented in class.**
   Materials to be used are slides, multimedia files, personal notes, and recommended books and magazines.

2. **Visits**
   Visits can be scheduled during the course prior agreement with the students, the university and the centres involved. The realization of these visits will be determined by the class schedule, the academic calendar, and the availability of the centres involved.

ASSESSMENT AND GRADING CRITERIA

Evaluation activities	Criteria	Weight
Written assessment Subtests: 10% Final test: 30%	Understanding of main concepts. Presentation and written communication.	40%
Lab assessment Lab protocols: 15% Behaviour in the lab: 5%	Understanding of concepts. Application of concepts to solve problems. Analysis and interpretation of results. Skills in the lab. Ability to write reports.	20%
Project assessment Report: 20% Presentation: 20%	Understanding of main concepts. Ability to write reports. Ability to report the work in a clear and precise way through talk.	40%

GRADING AND COURSE RULES

Grading

Regular assessment

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

- 40% comes from written examinations.
- 20 % comes from lab protocols and behaviour in the lab.
- 40% comes from project report and oral presentation.

Retakes

- 100% from an written examination

Course rules

- Class attendance is mandatory according to Article 93 of the General Regulations (Reglamento General) of Comillas Pontifical University and Article 6 of the Academic Rules (Normas Academicas) 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.
  - Regarding laboratory, absence to more than 15% of the 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 4.00 on the final test, a lower rating will be a fail in the subject.
- Students must obtain a minimum score of 5.00 on both the project report and presentations, a lower rating will be a fail in the subject.

WORK PLAN AND SCHEDULE[1]

Independent Study Activities	Date	Delivery date
• 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 presentation.	At the end of the course	
• Lab assessments.	During the course	
• Written examination.	During the course	
• Final examination.	At the end of the course	

STUDENT WORK-TIME SUMMARY			
CLASSROOM SESSIONS			
Theoretical Classes	Laboratory Practices	Presentations/Final Evaluation	
19	6	5	
INDEPENDENT STUDY			
Self-study on theory	Self-work on Lab Protocols	Preparation for Examinations	Preparation for Presentations
15	9	20	20
		ECTS:	3 (94 hours)

BIBLIOGRAPHY

Bibliography

- PDF versions of slides showed at class and posted on the website of the subject.
- Class notes.

Additional Bibliography

- 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.

[1] A detailed work plan of the subject can be found in the course summary sheet (see following page). Nevertheless, this schedule is tentative and may vary to accommodate the rhythm of the class.

Week	Hours	Units	TIME DISTRIBUTION OF LESSONS IN NANOTECHNOLOGY (2016-2017)	
Week	**Hours**	**Session**	**Topics**	**Hours**
09-13 January	1-2º	Unit 0	Presentation of the subject	2
16-20 January	3º	Unit 1	Introduction to the nanoworld	1
16-20 January	4º	Unit 2	2.1 Basics on quantum mechanics. 2.2 Chemical bonding and crystal structure.	2
23-27 January	5º		2.3 Volumetric or 3D materials. 2.4 Spatial confinement.	
23-27 January	6º	Unit 3	3.1 Mechanics and fluid mechanics	3
30-03 February	7º		3.2 Electronics and photonics	
30-03 February	8º		3.3 Biology and medicine.	
06-10 February	9º	Lab	Lab session 1	2
06-10 February	10º		Lab session 1	
13-17 February	11º	Subtest	Units 1, 2, 3	1
13-17 February	12º	Unit 4	4.1 Bottom-up and top-down approaches.	3
20-24 February	13º		4.2 Nanofabrication by particle beams.4.3 Nanofabrication by replication and pattern transfer.	
20-24 February	14º		4.4 Nanofabrication by self-assembly. 4.5 Nanofabrication by scanning probes. 4.6 Indirect nanofabrication.	
27-03 March	-	Subtest	Midterm exam (Unit 1, 2, 3, 4)	-
06-10 March	15º	Lab	Lab session 2	6
06-10 March	16º		Lab session 2	
13-17 March	17º		Lab session 3	
13-17 March	18º		Lab session 3	
20-24 March	19º		Lab session 4	
20-24 March	19º		Lab session 4	
27-31 March	21º	Unit 5	5.1 Structural and morphological characterization.	4
27-31 March	22º		5.2 Compositional characterization.	
03-07 April	23º		5.3 Optical characterization.	
03-07 April	24º		5.4 Mechanical characterization. 5.5 Synchrotron and accelerators as characterization facilities.	
10-14 April	25º	Subtest	Unit 5	1
10-14 April	26º	Projects	Projects presentations	5
17-21 April	27º		Projects presentations	
17-21 April	28º		Projects presentations	
24-28 April	29º		Projects presentations	
24-28 April	30º		Projects presentations	