COURSE SYLLABUS
2015-2016

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	Joaquín Tutor-Sánchez

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Teacher	
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SPECIFIC SUBJECT DATASHEET

Subject contextualization

Contribution to the professional profile of the Title

This subject has been designed to give the students a fundamental understanding of the integrated multidisciplinary nature of Nanotechnology. It will also be a forum for discussion on the possible consequences of such technological development. This is an introductory course to deal some of the fundamental principles about Nanoscience and Nanotechnology, as well as the applications of Nanotechnology in particular to the energy sector. The role of solid-state physics and chemistry in nanotechnology is emphasized. Nanoscale tools such as surface probe and atomic force microscopy, nanolithography. Special topics such as molecular electronics are also covered.

On completion of this course, students should be able to:

- understand how basic nanosystems work;
- use physical reasoning to develop simple nanoscale models to interpret the behaviour of such physical systems;
- report their work in a clear and precise way through talks and reports;
- understand the major issues in producing a sustainable nanotech industry

Pre requirements

There are not needed any prerequisites to study the subject. However 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.

Computer and Technical Requirements. Microsoft Word and Microsoft PowerPoint are useful for writing reports and presentations.

THEME TITLES AND CONTENTS

Theme Titles - Contents
PART 1: NANOTECHNOLOGY
Unit 1: WHY NANOSTRUCTURES?
Scientific knowledge of the matter: From the macro-scale to nano-scale. Nanoscience or nanotechnology? Some key personalities: R. Feynman, Leo Esaki, N. Taniguchi, E. Drexler. Nanotechnology: the kingdom of quantum mechanics. Effects of confinement: energy levels. Properties of nano-objects. Effect of classical and quantum size. Emergency and convergence of nanotechnology. Multidisciplinary nature of nanotechnology. Wide range of applications of nanotechnology. Status of nanotechnology in various regions of the world: investment and centers. Evolution of patents and publications in nanotechnology. The situation in Spain, networks, facilities and funding.
Unit 2: NANOSTRUCTURES BY THEIR SIZES.
Materials 3D. Materials 2D (with confinement effects in one direction). Materials 1D (with confinement effects in two directions). Materials 0D (effects of confinement in three directions).
Unit 3: NANOSTRUCTURES BY ITS APPLICATIONS
Electronics. Photonics. Aerospace. Biostructures. Medicine and Health. Controlled distribution of drugs. Image Processing. Cosmetics. Genomics, Proteomics and Bioinformatics. Surgery and Implants.
Unit 4: CHARACTERIZATION METHODS
Structural. Electrical. Mechanics. Optics.
Unit 5: NANOFABRICATION
Top-down techniques: descending or "top-down". Bottom-up techniques: ascending, or "bottom-up". Hybrid Techniques and nano-micro-macro integration.
PART 2 : NANOTECHNOLOGY APPLICATIONS TO THE ENERGY SECTOR
Unit 6: WORLD ENERGY OUTLOOK: ISSUES AND STRATEGIES.
Unit 7. NANOMATERIALS FOR ENERGY PRODUCTION AND CONVERSION
Photovoltaic Solar Energy. Solar Thermal Energy. Hydrogen Conversion. Thermal Energy and Bioenergetics.
Unit 8. NANOMATERIALS FOR ENERGY STORAGE
Rechargeable batteries. Hydrogen Storage. Supercapacitors.
Unit 9. NANOMATERIALS FOR SAVING ENERGY
Insulation. Combustion Processes. Lighter and stronger materials.
Unit 10. NANOMATERIALS FOR NEW SOURCES OF LIGHT
Optoelectronics. More efficient light sources. Light sources with higher lighting capacity.
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, both by industry and by universities.
Lab 2. Nanofabrication. Silver nanoparticles synthesis - 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 3. Nanocharacterization. AFM and STM.
In the third practice students will familiarize students with the structural characterization tools used in nanoscale science and engineering: Scanning probe microscopy. Students will learn about the basis of work of Atomic Force Microscopy (AFM) and Scanning Tunneling Microcopy (STM). The students will demonstrate the appropriate use such techniques of images processing and the information one can get from them.

Competences and Learning Outcomes

Competences

General Competences

CG4. Conduct research, development and innovation in products, processes and methods.

CG8. Apply the acquired knowledge to solve problems in new or unfamiliar environments within broader and multidisciplinary contexts.

CG10. Be able to clearly and unambiguously communicate conclusions –and the knowledge and rationale that support them–, to specialist and non-specialist audiences.

CG11. Acquire learning skills that will allow further study in a self-directed or autonomous manner.

Basic Competences

Specific Competences

CE1. Knowledge on basic concepts on Nanoscience and Nanotechnology that help the learning of new method and theories about the behavior of the matter at nanoscale. Student will be trained to be flexible in front of new challenges.

CE2. Ability to be creative, critical reasoning and to communicate knowledge and skills inside the Nanotechnology field.

CE3. Ability to handle new concepts of different nanostructure dimensions, fabrication and characterization techniques.

CE4. Ability to analyze and evaluate applications of Nanotechnology to different economical sectors, in particular to the energy sector.

Learning outcomes

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

RA1. To know why the nanostructures are important from the standpoint of science and technology.
RA2. To be able to differentiate nanostructures according to their dimensions and applications.
RA3. Explain qualitatively the nanostructures manufacturing and characterization methods.
RA4. Understand the current state of the global energy sector from the point of view of transformation, production, consumption and environmental effects.
RA5. Identify the Spanish situation regarding the energy sector.
RA6. Establish relevant effects of nanotechnology in the energy sector worldwide and particularly in Spain: research, development and business situations.
RA7. Explain the characteristics of nanotechnology applications for the conversion and production processes, storage and energy savings.
RA8. Determine the evolution of nanotechnology applications in optoelectronics and the design and manufacture of new light sources.

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-class activities

1. **Theoretical Classes:**
   Combination of teaching methods:
   - Theoretical
   - Experimental
   - Expository
   - Description
   - Historical – Logical
   - Home work
   - Discussion and exchange of views

2. **Laboratory practices.** Students will work in groups of three.

Out-of-class activities

1. **Self Study** on the concepts presented in class. Materials to be used are slides, multimedia files, personal and teacher notes, recommended books and magazines.
2. **Team Works**. Preparation of Lab protocols as well as preparation and presentation of project reports for final examination. Students must find the information sources to create outstanding works.

Main target of the Independent Study is to be able to understand theoretical concepts and to be able to apply them.

ASSESSMENT AND GRADING CRITERIA

Evaluation activities	Criteria	Weight
FINAL ASSESSMENT • Written examination	Final examination about all the topics dealt during the development of the Subject Matter	40%
PROJECT ASSESSMENT • Project report • Oral presentation on the project	One of the projects offered will be chosen by a student group (**2-3 students decided by the Teacher**) and the evaluation will consist in submit the project report and an oral presentation of the project if the semester schedule allows. The project report will stretch 10 to 15 pages including figures, tables, and references. The report must be submitted to the teacher before the oral presentation. In case of presentations they will hold in the last week of the course.	40%
FREQUENT ASSESSMENT • Questions in class • Laboratory practices	- Concepts understanding. - Concepts applied to laboratory practices	20%

GRADING AND COURSE RULES

Grading

Regular assessment

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

- 40% comes from a written examination during the period of final exams
- 40% comes from project report and an oral presentation at the end term
- 20% comes from frequent assessment.

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).

WORK PLAN AND SCHEDULE[1]

Independent Study Activities	Date	Delivery date
• Reading of multimedia files to be showed in class (Slides)	Before lesson	
• Study on the slides showed in class.	After lesson	
• Study with additional information coming from other sources: class notes, books, etc.	After lesson	
• Project report; Oral presentation on the project	At the end of the course	
• Frequent assessments	During the course	
• Final assessment	April	

STUDENT WORK-TIME SUMMARY			
CLASSROOM SESSIONS			
Theoretical Classes	Laboratory Practices	Presentations/Final Evaluation	
14	8	4	
INDEPENDENT STUDY			
Self study on theory	Self work on Lab Protocols	Preparation for Examination	Preparation for Presentations
28	20	10	10
		ECTS:	3 (94 hours)

BIBLIOGRAPHY

Bibliography
• Class notes and pdf versions of slides • Journal articles
Additional Bibliography
• Ben Rogers, Sumita Pennathur Jesse Adams. Nanotechnology; Understanding Small Systems. Second Edition. CRS Press. 2011 • Susana Horning Priest. Nanotechnology and the Public: Risk Perception and Risk Communication. First Edition. CRS Press. 2012

[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.

TIME TABLE OF NANOTECHNOLOGY Subject Matter COURSE 2015-2016

Monday 8:00 to 9:50	TOPICS	ACTIVITY		COMMENTS
		TYPE	PLACE	
11- Jan	Why Nanostructures?	Theory	Classroom 310	
18-Jan	Nanostructures according to dimensions and to applications	Theory	Classroom 310	
25-Jan	Nanocharacterization and Nanofabrication	Theory	Classroom 310	
1-Feb	Present situation of the Energy Sector	Theory	Classroom 310	
15-Feb	Nanotechnology: Energy Production, conversion and storage	Theory	Class room 310	
22- Feb	Lab 1 Simulation of nanostructures: Groups 1, 2, 3	Practice	Classroom 105	Materials Studio Software
	Lab 2 Nanofabrication: Groups 4, 5, 6	Practice	Chemistry Lab	
	Lab 3 Nanocharacterization: Groups 7,8,9	Practice	Materials Lab	
29-Feb	Nanotechnology: Energy saving	Theory	Classroom 310	
7-Mar	Lab 1 Simulation of nanostructures: Groups 4, 5, 6	Practice	Classroom 105	Materials Studio Software
	Lab 2 Nanofabrication: Groups 7, 8, 9	Practice	Chemistry Lab	
	Lab 3 Nanocharacterization: Groups 1, 2, 3	Practice	Materials Lab	
14-Mar	Nanotechnology: New light sources	Theory	Classroom 310	
4-Apr	Lab 1 Simulation of nanostructures: Groups 7,8,9	Practice	Classroom 105	Materials Studio Software
	Lab 2 Nanofabrication: Groups 1, 2, 3	Practice	Chemistry Lab	
	Lab 3 Nanocharacterization: Groups 4, 5, 6	Practice	Materials Lab	
11-Apr	1st Section for Oral Presentations	Assessment	Classroom 310	EVALUATION
18-Apr	2nd Section for Oral presentations	Assessment	Classroom 310	EVALUATION
25-Apr	FINAL EXAMINATION	Written exam	Classroom 310	EVALUATION