Universitat Autònoma de Barcelona

**2020/2021**

# Introduction to Nanoscience and Nanotechnology

Code: 103291
ECTS Credits: 6

| Degree | Type | Year | Semester |
|---|---|---|---|
| 2501922 Nanoscience and Nanotechnology | OB | 1 | A |

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

## Contact

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## Use of Languages

Principal working language: spanish (spa)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: Yes

## Prerequisites

No prerequisites are needed

## Objectives and Contextualisation

Nanotechnology is emerging as a very powerful tool capable of revolutionizing and changing our way of life. Nano-objects and nanostructures exhibit new phenomena and properties that are unthinkable in the macroscopic world. Such new phenomena and properties can be exploited to provide solutions for the great social challenges in medicine, energy and the environment. The student is invited to embark on a fascinating journey to discover the great power of the small.

The objective of the subject is to familiarize the student with the concept of nanoscience and nanotechnology and to provide a thorough grounding of the scientific reasons behind the different behaviour that materials exhibit when they are miniaturized and how the nanomaterials can be observed, manipulated or synthesized in the nanoscale. On the other hand, it is intended to explain and raise awareness of the use of these nanomaterials for innovative technological developments in areas such as health, environmental remediation, information / communication, energy production / storage, synthesis and manufacturing of new materials, etc.

It is also expected that the student becomes aware of the multidisciplinary training that must be acquired to work in this field and the ethical, social and risk implications that these new disciplines may entail. The course will be complemented by some demonstrative practices in the classroom that will help to understand the fascinating world of materials at the nanoscale level.

## Competences

- Adapt to new situations.
- Be ethically committed.
- Communicate orally and in writing in ones own language.
- Demonstrate knowledge of the concepts, principles, theories and fundamental facts related with nanoscience and nanotechnology.
- Lead and coordinate work groups.
- Learn autonomously.

- Manage the organisation and planning of tasks.
- Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
- Perform correct evaluations of the environmental and socioeconomic impact of chemicals and nanomaterials.
- Reason in a critical manner
- Recognise the terms used in the fields of physics, chemistry, biology, nanoscience and nanotechnology in the English language and use English effectively in writing and orally in all areas of work.
- Resolve problems and make decisions.
- Show sensitivity for environmental issues.
- Work correctly with the formulas, chemical equations and magnitudes used in chemistry.

## Learning Outcomes

1. Adapt to new situations.
2. Be ethically committed.
3. Communicate orally and in writing in ones own language.
4. Correctly apply chemical and physical protocols in accordance with application to the evaluation of the environmental risks of products derived from nanotechnology.
5. Describe examples of elements, materials, devices and systems that exist in nature and that have specific properties because of their nanometric dimensions.
6. Describe from an interdisciplinary and transversal point of view the impact of nanoscience and nanotechnology on society
7. Describe generically the techniques for observation, characterisation, detection and manipulation of properties on a nanoscale.
8. Describe the historical evolution of nanoscience and nanotechnology as well as their main contributions to society
9. Describe the main fields of application of nanoscience and nanotechnology and their prospects.
10. Describe the main physical and chemical properties dependent on the size of materials.
11. Identify and define what is understood by nanoscience and nanotechnology.
12. Identify the main topics of modern-day science.
13. Interpret texts and bibliographies in English on each of the techniques, methodologies, tools and instruments used in the subject.
14. Lead and coordinate work groups.
15. Learn autonomously.
16. Manage the organisation and planning of tasks.
17. Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
18. Reason in a critical manner
19. Recognise the risks to the environment associated to the manipulation of products derived from nanotechnology.
20. Recognise the terms used in topics related to nanoscience, nanotechnology and society.
21. Resolve problems and make decisions.
22. Show sensitivity for environmental issues.
23. Work correctly with the formulas, chemical equations and magnitudes used in chemistry.

## Content

1.- Introduction to nanoscience and nanotechnology.

Nanoscience and nanotechnology concept. The nanometric scale. Nanotechnology applications. Economic, environmental, social and ethical implications and perspectives. Nanomaterials in History and Nature. Bioinspiration.

Size dependent properties.

Superficial effects. Importance of the surface at the nanoscale. The surface / volume ratio. Surface energy and surface tension. Surface Reactivity and Catalysis. Superficial reconstruction / relaxation. Adsorption, electric double layer.

Quantum effects. Classical theory vs. Quantum theory. Black body radiation. Photoelectric effect. The Rutherford and Bohr atom. The electron as wave and particle. Wave function and uncertainty principle. Schroedinger equation. Particle in a box. Tunnel effect. Confinement effect.

2.- Nanomaterials

Carbon and Graphene Nanotubes: synthesis, properties and applications. Colloids and their properties. Metallic, semiconductor and magnetic nanoparticles. Synthesis of nanoparticles, properties, applications in sensors, catalysis and nanomedicine. Nanomaterials based on lipids, polymers and proteins: properties and applications. Intelligent materials that respond to stimuli, self-repairing nanomaterials. Nanoporous and nanostructured materials. Molecular motors.

Self-assembly and hierarchical organization concept. Design of materials from the autoassociative properties of DNA and proteins.

3. Characterization Techniques.

Techniques based on sample / radiation interaction: light microscopy. Infra-red spectroscopy, Raman effect. Absorption of UV-visible radiation. Fluorescence and phosphorescence. Fluorescence and confocal light microscopy. X-ray absorption, X-ray photoelectronic spectroscopy, X-ray diffraction. Ellipsometry. Synchrotron radiation.

Techniques based on sample / electron interaction. Phenomena that appear from the electron / matter interaction. Scanning electron microscopy. Transmission Electron Microscopy. X-ray scattering spectroscopy.

Proximity techniques. Different techniques based on a tip in proximity to the sample. Tunnel effect microscopy. Atomic microscopy of forces and their variants. Force spectroscopy.

4. Nanofabrication Techniques

Top-down / bottom-up approach. Photolithography. Electron-based lithography. Lithography based on tunnel effect microscopy and atomic force microscopy. Dip-pen nanolithography. Integration of devices for electronic, optical, telecommunications, medical applications, (bio) sensor applications, etc.

## Methodology

The methodology consists of directed, supervised and autonomous type activities.

## Activities

| Title | Hours | ECTS | Learning Outcomes |
|---|---|---|---|
| Type: Directed | | | |
| Problem solving classes | 5 | 0.2 | 3, 6, 9, 5, 7, 8, 10, 16, 11, 13, 22, 18, 20, 21, 23 |
| Theoretical classes | 40 | 1.6 | 6, 9, 5, 7, 8, 10, 11, 13, 20 |
| Type: Supervised | | | |
| Debates: case analysis | 10 | 0.4 | 3, 6, 5, 7, 8, 10, 16, 11, 13, 22, 18, 20, 21, 23 |
| Type: Autonomous | | | |

| | | | |
|---|---|---|---|
| Learning | 70 | 2.8 | 1, 15, 3, 6, 9, 5, 7, 8, 10, 16, 12, 11, 13, 2, 22, 17, 18, 20, 21, 23 |
| Presentations | 10 | 0.4 | 15, 6, 9, 5, 7, 8, 10, 16, 11, 13, 17, 18, 20, 23 |
| excercises | 10 | 0.4 | 6, 5, 7, 10 |

## Assessment

Exams: 2 written partial exams on the concepts taught in classes. The first partial will have a weight of 24% while the second will have a weight of 56%. To pass the course, it is a condition that the minimum average grade for exams (obtained with their corresponding weights) is 5. In turn, the average grade for the exams will have an overall weight of 80% in the final grade.

Problems and presentations: delivery of solved problems and / or oral presentations. Overall weight 20% in the final grade.

## Assessment Activities

| Title | Weighting | Hours | ECTS | Learning Outcomes |
|---|---|---|---|---|
| 2 partial exams | 24% and 56% respectively | 4 | 0.16 | 15, 3, 6, 9, 5, 7, 8, 10, 12, 11, 2, 18, 20, 21 |
| Delivery of works or oral presentations | 20% | 1 | 0.04 | 1, 4, 15, 3, 6, 9, 5, 7, 8, 10, 16, 12, 11, 13, 14, 2, 22, 17, 18, 19, 20, 21, 23 |

## Bibliography

- Nanoscience and Nanotechnology. Between the science fiction of the present and the technology of the future. Authors: José Angel Martín Gago, Carlos Briones Llorente, Elena Casero Junquera, Pedro Aemlio Serena Domingo

- Introduction to Nanoscience and Nanotechnology. Authors: Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta, John J. Moore.

- Introduction to Nanotechnology. Authors: Charles P. Poole Jr. and Frank J. Owens.