

**Advanced Physical Properties of Nanomaterials**

Code: 43437  
ECTS Credits: 6

| Degree  | Type | Year | Semester |
|---|------|------|----------|
| 4314939 Advanced Nanoscience and Nanotechnology | OT   | 0    | A        |

## Contact

Name: Javier Rodríguez Viejo

Email: Javier.Rodriguez@uab.cat

## Use of languages

Principal working language: english (eng)

## External teachers

Alejandro Goñi

Anna Palau

Javier Rodríguez

Jordi Sort

## Prerequisites

Basic Knowledge of Solid State, quantum mechanics and basic concepts of Materials Science.

## Objectives and Contextualisation

Deepen the understanding of size effects in the properties of low-dimensional materials.

## Skills

- Analyse the benefits of nanotechnology products, within one's specialisation, and understand their origins at a basic level
- Continue the learning process, to a large extent autonomously
- Design processes for nanomaterials with properties and functionalities default (specialty Nanomaterials).
- Identify the characterisation and analysis techniques typically adopted in nanotechnology and know the principles behind these, within one's specialisation.
- Show expertise in using scientific terminology and explaining research results in the context of scientific production, in order to understand and interact effectively with other professionals.
- Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
- Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.

## Learning outcomes

1. Assess the importance of scale for describing advanced physical properties in materials, whether electronic, optical, magnetic, mechanical or transport-related.

2. Continue the learning process, to a large extent autonomously
3. Describe in qualitative terms the principles behind superconductivity and know its applications.
4. Identify the emergence of thermoelectric phenomena at the nanometric scale.
5. Interpret the phenomena of light absorption and emission, both interband and intraband, in nanostructures.
6. Interpret the results of experimental measurements on the basis of the theoretical principles acquired.
7. Interpret the variation of electronic properties of solids with the dimensionality of the system based on advanced band theory models.
8. Make calculations on the physical properties of materials in nanometric-scale systems.
9. Recognise the concept of transmission in ballistic transport and formulate problems and solutions in the field of low-dimensionality devices.
10. Recognise the different methods of characterisation and the principles behind them on the basis of the physical property to be measured.
11. Recognise the importance of spin in transport and understand the workings of spintronic devices.
12. Show expertise in using scientific terminology and explaining research results in the context of scientific production, in order to understand and interact effectively with other professionals.
13. Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
14. Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.

## Content

*Electronic and Optical properties: Energy bands. K.p and pseudopotentials. Optical properties of low-dimensional semiconductors. Light absorption. Spontaneous and stimulated emission. Luminescence. Pressure effects.*

*Transport: electrons and phonons. kinetic theory. Boltzmann transport equation. Landauer formalism: Conductance and fluxes. Application to low-dimensional semiconductors and graphene. Thermoelectric effects in semiconductor nanostructures.*

*Mechanical properties: Correlation of the microstructure with mechanical properties: Hall-Petch effect. Nanoindentation: Oliver & Pharr Method. Size effects. Nanoindentation in crystalline and amorphous solids*

## Methodology

**Lessons:** The teacher explains the most important concepts of each subject. The notes will be available at the Virtual campus or distributed by the professor. Els alumnes disposen d'apunts al campus virtual o de còpia de les transparències en format pdf amb antelació i dins el campus virtual de la UAB.

**Discussion lectures:** reading of scientific articles and their discussion in class.

**Supervised activities:** In specified hours the teachers will be accessible to discuss the contents of their respective subjects.

**Activitats formatives autònomes:** Solving problems.

**Handouts:** teachers can ask for research or bibliographic works to consolidate the contents of every subject.

**Study for exams:** Personal work by the student.

## Activities

| Title                 | Hours | ECTS | Learning outcomes |
|-----------------------|-------|------|-------------------|
| <b>Type: Directed</b> |       |      |                   |

|                         |    |      |                 |
|-------------------------|----|------|-----------------|
| regular teaching        | 46 | 1.84 | 3, 7, 9, 11, 13 |
| supervised              | 14 | 0.56 | 2, 13, 14       |
| <b>Type: Autonomous</b> |    |      |                 |
| autonomous work         | 77 | 3.08 | 2, 3, 7, 9, 11  |

## Evaluation

Final exams (50-60%).

Handouts: (40-50%).

It is possible to have the chance to increase the marks of the synthesis exams in an extra test (only for those students that have carried out all previous evaluations along the course).

## Evaluation activities

| Title    | Weighting | Hours | ECTS | Learning outcomes               |
|----------|-----------|-------|------|---------------------------------|
| Exams    | 50-60%    | 3     | 0.12 | 1, 3, 4, 5, 7, 8, 9, 11, 12, 13 |
| Handouts | 40-50%    | 10    | 0.4  | 1, 2, 6, 8, 10, 12, 14          |

## Bibliography

Teachers of the various subjects will provide references for books and scientific articles the first day of the activity.