UAB
Universitat Autònoma de Barcelona

Solid State

Code: 103288
ECTS Credits: 7

2024/2025

Degree	Type	Year
2501922 Nanoscience and Nanotechnology	OB	3

Contact

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Teachers

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

It is convenient to have some knowledgment on the following topics

-Electromagnetism

-Quantum Physics

-Mechanics

-Calculus

Objectives and Contextualisation

To understand the characteristics of solid-state

To understand how the properties (thermal, optic, magnetic, ...) of solids lead to new phenomena.

To introduce some of the basic experimental techniques for the study of solid-state.

More specifically, to understand:

- Periodic structures
- Phonons
- Electronic states and energy bands

- Magnetic materials

Competences

- Apply the concepts, principles, theories and fundamental facts of nanoscience and nanotechnology to solve problems of a quantitative or qualitative nature in the field of nanoscience and nanotechnology.
- Apply the general standards for safety and operations in a laboratory and the specific regulations for the use of chemical and biological instruments, products and materials in consideration of their properties and the risks.
- Communicate orally and in writing in one's own language.
- Demonstrate knowledge of the concepts, principles, theories and fundamental facts related with nanoscience and nanotechnology.
- Handle the standard instruments and materials of physical, chemical and biological testing laboratories for the study and analysis of phenomena on a nanoscale.
- Interpret the data obtained by means of experimental measures, including the use of computer tools, identify and understand their meanings in relation to appropriate chemical, physical or biological theories.
- Learn autonomously.
- Manage the organisation and planning of tasks.
- Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
- Propose creative ideas and solutions.
- Reason in a critical manner
- Recognise and analyse physical, chemical and biological problems in the field of nanoscience and nanotechnology and propose answers or suitable studies for their resolution, including when necessary the use of bibliographic sources.
- 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.

Learning Outcomes

1. Analyse situations and problems in the field of physics and propose answers or studies of an experimental nature using bibliographic sources.
2. Apply the acquired theoretical contents to the explanation of experimental phenomena.
3. Communicate orally and in writing in one's own language.
4. Correctly handle the necessary materials and instruments to characterise the physical properties of crystalline materials.
5. Critically evaluate experimental results and deduce their meaning.
6. Critically evaluate the results of calculations of the properties of solids and deduce their meaning
7. Describe the electronic states in metals, insulation and semiconductors.
8. Describe the periodicity of solids and the use of Schrödinger's glass equation to determine the formation of energy bands.
9. Differentiate between the different types of solids in accordance with energy bands and the fundamental consequences of these on their properties.
10. Differentiate types of magnetic materials in accordance with spin order and the main magnetic interactions.
11. Draft reports on the subject in English.
12. Employ information and communication technology in the documentation of cases and problems.
13. Identify and analyse problems related with the structure of solids.
14. Identify and situate safety equipment in the laboratory.
15. Identify the wave nature of lattice vibrations and their quantum description and apply these concepts to describe the thermal properties of different types of solid.

16. Interpret analysis results and assess their quality, relating them to the previous information on the sample.
17. Interpret basic texts and bibliographies in English on physics and materials.
18. Interpret the influence of periodicity on the properties of crystalline solids.
19. Learn autonomously.
20. Make adequate use of laboratory materials and instruments.
21. Manage the organisation and planning of tasks.
22. Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
23. Perform bibliographic searches for scientific documents.
24. Predict the thermal, mechanical, electrical, magnetic and optical properties of crystalline and amorphous materials, and nanomaterials on the basis of their composition and structure.
25. Present brief reports on the subject in English.
26. Propose creative ideas and solutions.
27. Propose simulations to obtain information on the energy and electronic structure of well described crystalline solids.
28. Reason in a critical manner
29. Recognise the quantum nature of the thermal properties of solids.
30. Recognise the strategy for modelling solids applied to examples found in bibliographic sources.
31. Recognise the terms for processes and devices for the generation, storage and transport of energy, as well as the applications and impact of nanomaterials on the environment.
32. Relate experimental data with the physical and chemical properties and/or analysis of the systems that are the object of study.
33. Resolve problems and make decisions.
34. Resolve problems with the help of the provided complementary bibliography.
35. Safely handle gases, especially inflammable ones.
36. Safely handle laboratory materials and instruments.
37. Show sensitivity for environmental issues.
38. Understand the absorption and emission of light in semiconductor materials with optical and optoelectronical properties.
39. Use data processors to produce reports.
40. Use databases of crystalline structures, of powder diffraction and other related bibliographic data

Content

A. Introduction

1. What do we mean by "Solid State"?
2. Properties of solids (thermal, conduction, optical, magnetic...)

B. Crystal structure

1. Symmeties and lattices
2. Reciprocal lattice and diffraction
3. Crystal binding

D. Lattice vibrations

1. Elastic waves
2. Phonons

C. Electrons in solids

1. Free electrons
2. Nearly free electrons
3. Electrons in periodic potentials
4. Band structure: insulators, metals, semiconductors

5. Semiclassical model for conduction

E. Magnetism and magnetic properties

1. Para- and dia- magnetism
2. Spontaneous order
3. Domains and hysteresis
4. Micromagnetic modeling

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Theory	112	4.48	2, 19, 5, 3, 7, 8, 10, 9, 12, 25, 23, 21, 13, 15, 18, 17, 37, 22, 27, 24, 26, 28, 31, 30, 29, 11, 38
Type: Supervised			
Laboratory	28	1.12	1, 2, 19, 6, 5, 3, 12, 25, 23, 21, 14, 16, 17, 35, 4, 36, 37, 22, 28, 31, 11, 32, 34, 33, 40, 20, 39
Problems	27	1.08	1, 2, 19, 6, 5, 3, 12, 25, 23, 21, 13, 16, 17, 37, 22, 27, 26, 28, 31, 30, 11, 32, 34, 33, 40

Theory:

- Explanation of the basic contents. Using the recommended bibliography, they can go deeply into the concepts already discussed in class.
- Deep explanation of the most important concepts, using examples, experimental evidences, and (when convenient) original works.

Problems:

- Solution of some of the basic problems/examples given to the students

Laboratory:

- To be determined.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Evaluation of	20%	0	0	19, 3, 25, 21, 14, 16, 17, 35, 4, 36, 37, 22, 26, 28, 31, 11, 32, 33,

Laboratory work				20, 39
Partial exam 1	30%	2.5	0.1	1, 2, 19, 6, 5, 3, 8, 25, 21, 13, 15, 18, 24, 28, 31, 30, 29, 11, 38, 33, 40
Partial exam 2	50%	2.5	0.1	1, 2, 19, 6, 5, 3, 7, 8, 10, 9, 12, 21, 13, 15, 18, 27, 24, 26, 28, 30, 29, 38, 33, 40
Retake Exam	Up to 80%	3	0.12	1, 2, 19, 6, 5, 3, 7, 8, 10, 9, 12, 25, 23, 21, 13, 15, 16, 18, 17, 22, 27, 24, 26, 28, 31, 30, 29, 11, 38, 32, 34, 33, 40

The final grade of the course will be obtained using the following proportions:

- Partial Exam 1 (30%). Consisting in a combination of theoretical questions and problems to be solved related to 1st part of the course
- Partial Exam 2 (50%). Consisting in a combination of theoretical questions and problems to be solved related the 2nd part of the course.
- Retake exam. Each part could be retaken independently, substituting the previus grade with the new one.
- Laboratory work: 20%. Written reports about the methodology, experimental results and their interpretation. No retaken option.

Only if the overall average score is equal to or higher than 5.0 (out of 10) the subject can be passed.

UAB Regulations: To be able to retake partial exams, the student must have previously been evaluated in a set of activities the weight of which is equivalent to a minimum of two-third parts of the total qualification of the subject.

Students who have been evaluated only 1/3 or less of the total evaluation will be considered "Not Evaluable".

Single Evaluation: The students with single evaluation have to pass a single exam, done the same day as the 2on partial (80% of the total qualification). That same day, they have to deliver all the lab reports (20%). If necessary, the retake exam will be done the day designed from the Coordination. The single evaluation exam is not splited, so the retake exam is not splited and must be done for the whole 80% of the qualification.

In the event that the student realizes any irregularity that might lead to a significant variation in the qualification of evaluation activity, he or she will qualify with 0 this evaluation activity, irrespective of the disciplinary process that could be started. If there are several irregularities in the evaluation of the same subject, the final qualification of this subject will be 0.

Any plagiarism (total or partial), copying or attempted copying, letting oneself be copied, etc., in any of the evaluable activities will be considered "irregularities leading to a significant variation in the qualification".

Bibliography

- C. Kittel. Introduction to solid state physics. (John Wiley and Sons).
- N. W Ashcroft and N. d. Mermin, Solid State Physics (Saunders College)
- H. J. Goldsmid. Problems in Solid State Physics (Pion Limited)

Software

No specific software is needed.

Language list

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	1	Catalan	second semester	afternoon
(PLAB) Practical laboratories	1	Catalan	second semester	morning-mixed
(PLAB) Practical laboratories	2	Catalan	second semester	morning-mixed
(PLAB) Practical laboratories	3	Catalan	second semester	morning-mixed
(PLAB) Practical laboratories	4	Catalan	second semester	morning-mixed
(TE) Theory	1	Catalan	second semester	afternoon