UAB
Universitat Autònoma de Barcelona

Solid State Physics

Code: 100175
ECTS Credits: 6

2024/2025

Degree	Type	Year
2500097 Physics	OT	4

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 highly recommended to have basic notions of Quantum Physics and Thermodynamics.

Objectives and Contextualisation

This course deals with the study of some fundamental properties of the solid materials.

The interaction of two particles or one particle in an external potential is usually studied. In the real world there are almost never two particles, it is much more complex, there are many particles (on the order of Avogadro's number). But most of the things we handle are solid: mechanical tools, motors, radio, TV, mobile, etc. Although in principle, it would be enough to study these properties from the wave function solution of eq. Schrödinger, due to the high number of particles it is impossible and it is necessary to make approximations.

Solid State Physics is a very extensive subject, impossible to deal with in a subject of 6 credits, therefore, only the most basic properties of crystalline solids will be studied. They are fundamental for later studies or in many branches of research.

First it is necessary to know what a crystal is and analyze its symmetries.
Later we will see properties that are derived from these symmetries and that do not require solving the Schrödinger equation.
Finally, the Schrödinger equation for the electrons and ions in a crystal will be solved.
These solutions are the key to explain properties of solids such as: dielectric function, magnetism, conductivity, transparency, specific heat, etc.

Competences

- Apply fundamental principles to the qualitative and quantitative study of various specific areas in physics
- Be familiar with the bases of certain advanced topics, including current developments on the parameters of physics that one could subsequently develop more fully
- Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, and before both specialist and general publics
- Develop the capacity for analysis and synthesis that allows the acquisition of knowledge and skills in different fields of physics, and apply to these fields the skills inherent within the degree of physics, contributing innovative and competitive proposals.
- Formulate and address physical problems identifying the most relevant principles and using approximations, if necessary, to reach a solution that must be presented, specifying assumptions and approximations
- Know the fundamentals of the main areas of physics and understand them
- Make changes to methods and processes in the area of knowledge in order to provide innovative responses to society's needs and demands.
- Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
- Work independently, have personal initiative and self-organisational skills in achieving results, in planning and in executing a project
- Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.

Learning Outcomes

1. Apply the techniques studied in other disciplines such as crystallography and electron devices.
2. Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, in front of both specialist and general publics.
3. Define useful approaches for studying superconductivity.
4. Describe Schrödinger's equation for a crystal.
5. Describe the approaches needed to solve Schrödinger's equation for a crystalline solid.
6. Distinguish quasicrystal glass on the basis of its properties.
7. Identify and understand the general properties of a crystal.
8. Identify situations in which a change or improvement is needed.
9. Predict electron dynamics from a semiclassical model.
10. Simplify and solve the approximate equations of a crystal.
11. Solve equations that describe ion vibrations.
12. Use approximations to calculate the energy of electrons.
13. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
14. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.
15. Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.

Content

1. Symmetries and crystals
2. Diffraction by a crystal
3. Lattice vibrations: Classical theory and quantum formulation
4. Electronic models

5. Semiconductors
6. Superconductors

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Problem sessions	16	0.64	1, 2, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15
Theoretical sessions	32.75	1.31	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15
Type: Supervised			
survey of the subject	0.25	0.01	8, 13
Type: Autonomous			
Individual or group work	86	3.44	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15

In the theoretical sessions, the basic lines will be explained so that the student can work the subject in an efficient way, either individually or in groups.

In the problem classes, the difficulties encountered by the students when solving the exercises proposed will be solved.

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
First part test	40%	2.5	0.1	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
Moodle short tests	20%	10	0.4	1, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14
Second part test	40%	2.5	0.1	1, 2, 3, 4, 6, 7, 10, 11, 12, 13, 15

ORDINARY EVALUATION

The evaluation will consist of three parts:

1. Short written tests in some chapters and/or during practical sessions (20%).
2. Two partial exams (40% each).

A minimum score of 3.5 is required in all tests. To pass the subject, a score of 5 or higher is needed.

RECOVERY PROCESS

There will be a recovery test for each partial exam and a period to improve scores in written quizzes. Students can take the recovery test provided they have participated in activities that account for at least two-thirds of the total grade for the subject, and have a continuous assessment score of 2.5 or higher.

SPECIAL GRADES

Students who, during the course (excluding the recovery exam), only take 2 or fewer written continuous assessment tests will receive a "Not assessable" grade.

SINGLE EVALUATION

The single evaluation will take place on the same day as the second partial exam. It will include questions covering the entire syllabus in the written part. Additionally, a questionnaire on practical sessions will be required.

Bibliography

Basic

Theory

1. N.W. Ashcroft and N.D. Mermin, *Solid State Physics*. (Saunders Collegue, 1976) ISBN 0-03-083993-9 (Collegue Edition), 0-03-049346-3 (International Edition
2. C. Kittel, *Introducción a la Física del Estado Sólido*. (Reverté, 3a. edición, 1998). ISBN 84-291-4317-3
3. J. Maza, J. Mosqueira y J.A. Veira, *Física del estado sólido*, (Universidade de Santiago de Compostela, 2008; Manuais Universitarios, n. 8). ISBN 978-84-9750-906-0
4. J.M. Ziman, *Principios de la Teoría de Sólidos*. (Selecciones Científicas, 1969)

Problems

1. H.J. Goldsmid*, Problemas de Física del Estado Sólido* (Reverté, 1975). ISBN 84-291-4037-9
2. L. Mihaly and M.C. Martin, *Solid State Physics* (Jonh Wiley & Sons, Inc.,1996). ISBN 0-471-15287-0
3. J. Piqueras y J.M. Rojo, *Problemas de Introducción a la Física del Estado Sólido* (Alhambra, 1980). ISBN 84-205-0670-2

Avanced

J. Callaway, *Quantum Theory of the Solid State*. (Academic Press, Inc. 2on edition, 1991). ISBN 0-12-155203-9

Software

No special program is used.

Language list

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	1	Catalan	first semester	afternoon
(TE) Theory	1	Catalan	first semester	afternoon