SUBJECT TEACHING GUIDE

G1999 - Solid State Physics

Double Degree in Physics and Mathematics
Degree in Physics

Academic year 2023-2024

1. IDENTIFYING DATA						
Degree	Double Degree in Physics and Mathematics Degree in Physics			Type and Year	Compulsory. Year 3 Compulsory. Year 3	
Faculty	Faculty of Sciences					
Discipline	Subject Area: Quantum Physics and the Structure of Matter Central Module					
Course unit title and code	G1999 - Solid State Physics					
Number of ECTS credits allocated	6	Term		Semester based (2)		
Web						
Language of instruction	Spanish	English Friendly	Yes	Mode of delivery	Face-to-face	

Department	DPTO. CIENCIAS DE LA TIERRA Y FISICA DE LA MATERIA CONDENSADA
Name of lecturer	FRANCISCO JAVIER JUNQUERA QUINTANA
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Other lecturers	CESAR MORENO SIERRA

3.1 LEARNING OUTCOMES

- - Understand the electronic band structure in solids, its relationship with the discrete energy levels in molecules and its implications in the physical properties.
- Understand the basic differences between metals, semiconductors, and insulators.
- Understand the experimental results on solids, and obtain electronic and magnetic parameters from the comprehension of basic models.
- Understand the structure and properties of pure and doped semiconductor materials, and its application in electronic and optoelectronic devices.
- Understand cooperative properties in solids: ferroelectricity, ferromagnetism and superconductivity.

4. OBJECTIVES
To understand the first classical models for the description of the electrical behavior in metals and their limitations . To understand the importance of independent electron approximations. To understand the microscopic origin of electronic bands in periodic solids using a nearly free electron model (i.e., starting from a free-electron model) as well as a tight binding model (i.e., starting from free-atom levels). To understand the influence of electronic bands on the properties of materials. To understand the differences between metals, insulators and semiconductors. To understand the importance of Bloch's theorem and the origin of electrical resistivity. To understand the dynamics of electrons under electric and magnetic fields using a semiclassical model. To understand the importance of pure and doped semiconductor materials, analyzing their fundamental properties, as well as their basic applications (pn junction diodes, npn transistors, photoelectric cells, etc.). To understand the quantum origin of diamagnetism, paramagnetism and magnetic arrangements (ferromagnetism and antiferromagnetism). To know the basic phenomenology of superconducting materials, as well as the London and Gizburn-Landau phenomenological models and the fundamentals of BCS theory.

6. COURSE ORGANIZATION	
CONTENTS	
1	Objectives and historic introduction. Complexity of the physical phenomena in solids. Introduction to the basic approximations. Phases and phase transitions. Perspective of the topic.
2	Electronic structure models. Drude classical model. Independent electron model. Free electron models in solids (Sommerfeld model). Fundamentals of the band theory. Bloch theorem and its consequences. Electrons in periodic potentials: free electron models and tight binding models.
3	Semiconductors: fundaments and applications. Semiconductor devices: pn junctions and transistors. Electron dynamics in external fields.
4	Ferroelectricity. Order parameters. Ginzburg- Landau functionals. First and second order phase transitions. Electronic susceptibility. Piezoelectricity.
5	Magnetism. Introduction: origin of atomic magnetism. Diamagnetism. Atomic paramagnetism (Curie's law). Pauli paramagnetism. Curie-Weiss law. Exchange interaction. Magnetic order. Ferrimagnetism. Antiferromagnetism. Hysteresis, domains and Bloch walls.
6	Superconductivity. Introduction. Phenomenological models. Fundamentals of BCS microscopic theory. High temperature superconductivity.
7	Midterm exam 1: Blocks 1 and 2.
8	Midterm exam 2: Blocks 3 and 4.
9	Midterm exam 3: Blocks 5 and 6.
10	Final exam.

7. ASSESSMENT METHODS AND CRITERIA

Description	Type	Final Eval.	Reassessn	%
Midterm exam 1	Written exam	No	Yes	20,00
Midterm exam 2	Written exam	No	Yes	20,00
Midterm exam 3	Written exam	No	Yes	20,00
Final ordinary exam	Written exam	Yes	Yes	40,00
Final extraordinary exam	Written exam	No	No	0,00
TOTAL				100,00

Observations

Midterm exams do not eliminate material for the regular final exam.
Midterm exams with an average grade lower than 4.0 can be made up in the final exam if the final exam grade is higher than 6.0.

Observations for part-time students

For part-time students, the mark would be that of the final exam (100%).

8. BIBLIOGRAPHY AND TEACHING MATERIALS

BASIC

N. W. Ashcroft, N. D. Mermin, Solid State Physics (Holt, Rhinehart and Winston, 1976).
C. Kittel. Introducción a la Física del Estado Sólido (Reverté, 1993).
H. Ibach, H. Luth. Solid State Physics, an Introduction to Theory and Experiment (Springer-Verlag, 1995)