COURSE DATA

DATA SUBJECT

Code: 36660
Name: Materials Science and Solid State
Cycle: Undergraduate Studies
ECTS Credits: 6
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
1929 - Double Degree Program in Physics and Chemistry	Facultat de Física	5	First quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
1929 - Double Degree Program in Physics and Chemistry	Quinto Curso (Obligatorio)	COMPULSORY

COORDINATION

CORONADO MIRALLES EUGENIO

SUMMARY

The subject introduces the basic concepts underlying the field of Materials Science, with particular emphasis on their impact in chemistry, physics and biology. This includes, in a first part, the study of crystal and electronic structure of solids and its correlation with their physical and chemical properties, with special attention to electrical, magnetic, optical and mechanical properties. In the second part, materials are discussed in the context of their applications in energy, electronics, communication technologies and health. At last, this concepts are applied to advanced functional materials, such as porous materials, molecular conductors and superconductors, funcional polymers or graphene and other two-dimensional materials.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

COMPETENCES / LEARNING OUTCOMES

DESCRIPTION OF CONTENTS

1. Introduction

What is Materials Science? Impact and current scope. Types of materials.

2. Crystal structures

Unit cell, Bravais lattices, common crystal structures, the reciprocal lattice. Defects in solids, amorphous solids, mechanical properties. Vibrations in solids, thermal properties

3. Electronic structure of solids

Bloch functions; band structure; Fermi level; density of states. Electronic structure/electrical properties correlations: metals, semiconductors and insulators.

4. Optical properties

Light-matter interaction: optical absorption, reflexion and refraction, non-lineal optical properties. Optical absorption in semiconductors: direct and indirect band gap semiconductors. The concept of exciton; excitonic absorption and recombination; photoluminescence and electroluminescence. Laser emission: laser types. Plasmons in metallic materials.

5. Cooperative properties in matter

Magnetism: magnetic susceptibility and magnetization; magnetic interactions. Cooperative magnetism: ferromagnetism, antiferromagnetism; magnetic domains; magnons. Band structure. Superconductivity: Meissner effect; BCS microscopic theory, Cooper pairs. Type I and type II superconductors. High critical temperature superconductors. Josephson effect and superconducting devices.

6. Materials for energy and mobility

Photovoltaic energy: innovative materials and photovoltaic thin film devices for efficient generation of energy (molecular materials, hybrid perovskites); comparison/competition with silicon. Thermoelectric energy: thermoelectric materials. Energy storage: electrocatalysts and photocatalysts for green hydrogen production based on abundant metals, materials for hydrogen storage and delivery; batteries and supercapacitors based on innovative concepts and materials (solid state or redox flux batteries).

7. Materials for electronics and ICTs

Semiconducting materials for field-effect transitors. Photodetectors. Light-emitting optoelectronic materials and devices. Spintronic materials and devices: magnetic memories and sensors. Materials for quantum technologies; materials for neuromorphic technologies.

8. Materials for health

Design of functional molecules and nanomaterials that respond to exogenous or endogenous stimuli for biomedical applications (controlled release, implants, artificial organs, biomaterials). Nanomaterials with applications in molecular diagnosis by in vitro or imaging techniques (probes, biomarkers, biosensors, etc). Theranostic nanomaterials.

9. Advanced functional materials (synthesis, processing and applications)

Porous materials for capture, storage and release of molecules and metals; porous materials for catalysis; liquid crystals; materials for non-linear optics; molecular conducting and superconducting materials; functional polymers; smart materials.

10. Graphene and other 2D materials

Preparation of van der Waals materials and heterostructures. Physics of 2D materials: electrical, magnetic, optical and mechanical properties. Chemistry of 2D materials: functionalization and fabrication of hybrid heterostructures and nanocomposites, toxicity. Principal applications (energy, electronics, health, building).

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Tutorials	9,00
Theory	51,00
Total hours	**60,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	5,00
Individual or group project	0,00
Independent study and work	70,00
Preparation of lessons	0,00
Preparation for assessment activities	15,00
Resolution of case studies	0,00
Total hours	**90,00**

TEACHING METHODOLOGY

¿ **Lectures.-** In these classes the professor will give an overview of the topic under study with special emphasis new aspects or special complexity. These classes are complemented by personal study time indicated as non-cont hours.

¿ **Classes of problems.-** In these classes, the knowledge acquired by the students in the lectures will be applied solve specific problems. Students must previously work on the problems to be solved in the class. Solving th problems will be held at times by the teacher and otherwise by the students, either in group or individually.

Evaluable seminars.- Five seminars will be organized aimed at students and taught by professors and research who work in areas of knowledge directly related to the contents of the subject "Solid State Physics" inclueded in Physics Degree (Applied Physics and Condensed Matter Physics). Students' attendance at these seminars and preparation of a report defined by the seminar lecturer will be evaluable (see ¿Evaluation¿ section).

EVALUATION

The knowledge acquired will be evaluated by an examination, in the periods established by the Faculty, which make a contribution of 80% to the final grade.

The examination will consist of objective questions, dedicated to those knowledge considered as basic and numerical and relationship problems that require to contemplate aspects of the subject that appear in different top Students who do not pass in the first call must take the second exam.

The student's participation in any activity proposed, related to the subject, will be assessed, including:

- Problems and questions solving.
- Participation in seminars
- Reports on the content of theoretical classes and seminars

The overall note will be that of the exam (80%) plus the one obtained in all of the activities mentioned above (20 The evaluation method will be the same in both the first and second examination periods.

To approve the subject, a minimum grade of 5 must be reached in each of the evaluation sections.

Final warning

Copying or plagiarism of any assignment that is part of the evaluation will make it impossible to pass the course, the student will be subject to the appropriate disciplinary procedures.

Please note that, according to Article 13 d) of the University Student Statute (RD 1791/2010, December 30), "*it is duty of a student to refrain from using or cooperating in fraudulent procedures in evaluation tests, in the work perfor or in official University documents*".

REFERENCES

- The Oxford Solid State Basics Steven H. Simon, Oxford University Press 2013
- The Physics and Chemistry of Materials Joel I. Gersten and Frederick W. Smith 2001 Wiley
- Introduction to Optics I, Interaction of Light with Matter Ksenia Dolgaleva from the Synthesis Lectures on Materials and Optics © Springer Nature Switzerland AG 2022 DOI 10.1007/978-3-031-02387-3
- Introductory Solid State Physics. H. P. Myers. Ed. Taylor & Francis 1990
- The Oxford Solid State Physics, https://podcasts.ox.ac.uk/series/oxford-solid-state-basics
- Concepts of Materials Science. Adrian P. Sutton,FRS https://global.oup.com/academic/product/concepts-of-materials-science-9780192846440?prevNumResPerPage=20&prevSortField=1&start=40=en&cc=nl
- Organic Electronics: Foundations to Applications, Stephen Forrest. Oxford University Press.
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- Energy Materials Duncan W. Bruce, Dermot O'Hare, Richard I. Walton First published:9 February 2011 Wiley

- Nanobiomaterials Ed. R. Narayan. ScienceDirect 2017

- Magnetism in Condensed Matter. Stephen Blundell https://global.oup.com/academic/product/magnetism-in-condensed-matter-9780198505914?prevNumResPerPage=20&prevSortField=1&start=160=en&cc=nl

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- Electrical Properties of Materials. L. Solymar, D. Walsh, and R. R. A. Syms (2020) https://global.oup.com/academic/product/electrical-properties-of-materials-9780198829959?prevNumResPerPage=20&prevSortField=1&start=40=en&cc=nl

- A Materials Science Guide to Superconductors and How to Make Them Super. Susannah Speller https://global.oup.com/academic/product/a-materials-science-guide-to-superconductors-9780192858351?lang=en&cc=nl