

**COURSE DATA****DATA SUBJECT****Code:** 36660**Name:** Materials Science and Solid State**Cycle:** Undergraduate Studies**ECTS Credits:** 6**Academic year:** 2026-27**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-linear 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 transistors. 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 on new aspects or special complexity. These classes are complemented by personal study time indicated as non-contact hours.

¿ **Classes of problems.**- In these classes, the knowledge acquired by the students in the lectures will be applied to solve specific problems. Students must previously work on the problems to be solved in the class. Solving these 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 researchers who work in areas of knowledge directly related to the contents of the subject "Solid State Physics" included in the 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 will 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 topics. 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 performed 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
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- 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>
- Optical Properties of Solids. Mark Fox <https://global.oup.com/academic/product/optical-properties-of-solids-9780199573370?prevNumResPerPage=20&prevSortField=1&start=200=en&cc=nl>
- Properties of Materials. Anisotropy, Symmetry, Structure. Robert E. Newnham <https://global.oup.com/academic/product/properties-of-materials-9780198520764?prevNumResPerPage=20&prevSortField=1&start=220=en&cc=nl9780198520764?prevNumResPerPage=20&prevSortField=1&start=220=en&cc=nl>
- Band Theory and Electronic Properties of Solids. John Singleton <https://global.oup.com/academic/product/band-theory-and-electronic-properties-of-solids-9780198506447?prevNumResPerPage=20&prevSortField=1&start=20=en&cc=nl>
- 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>