Nanoscale Physics

Code: 106820
ECTS Credits: 6

2025/2026

Degree	Type	Year
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 required to have successfully completed the Semiconductor Devices and Quantum Phenomena II subjects.

Objectives and Contextualisation

The objective of this subject is to provide the basis for the student to understand the variation of the physical properties (electronic, optical, thermal and transport) of materials on the nanometer scale.

Learning Outcomes

1. CM18 (Competence) Solve problems resulting from the nanoscale by using calculation and simulation tools.
2. CM19 (Competence) Work independently to solve problems and practical cases related to nanoscale phenomena.
3. CM21 (Competence) Acknowledge the contribution women have made to the study of nanoscale phenomena.
4. KM32 (Knowledge) Describe the nanoscale effect on the electronic, thermal, optical, magnetic and transport properties of materials.
5. KM36 (Knowledge) Recognise the physical principles underlying photonic and nanophotonic systems.

6. SM30 (Skill) Predict the behaviour, properties and uses of nanomaterials and nano-systems as a consequence of low dimensionality.

Content

0. INTRODUCTION: Concepts of scale and dimensionality.

Relevant lengths and scales

1. Optical properties

Semiconductors: Excitons. Ligth Emission and absorption.

Metallic particles: Scattering Mie and Rayleigh. Plasmons.

2. Electronic properties under confinement and Electronic transport

Semiconductor quantum dots. Tight-binding model.

Landauer-Buttiker Formulism.

Ballistic transport.

Coulomb blockade

Quantum point contact and other examples

3. Thermal properties

Phonons

Heat capacity.

Temperature and melting of nanoparticles.

Thermal transport: Kinetic Theory. Boltzmann's equation. Ballistic phononic transport.

4. Thermoelectric phenomena

Depending on the health situation, and the need to do non-face-to-face teaching, it can be adapted.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lectures	28	1.12	
Practices	6	0.24	
Problems	13	0.52	
Type: Autonomous			

Study: exams, reports preparation, problem resolution	60	2.4

In this course, specific teaching is offered where there will be different formative activities that are described next. The work hours that are specified for each training activity correspond to an average student. Naturally, not all students need the same time to learn concepts and carry out certain activities, so the distribution of time should be understood as guidance. In this subject, we try to promote the active participation of the student as a relevant learning tool.

Direct training activities:

Master classes sessions: classes in which the theory teacher explains the most relevant concepts of each subject. Usually, they are blackboard classes, although in some cases classes are done with computer programs. Students have notes or copy of the transparencies in pdf format in advance uploaded in the virtual campus of the UAB.

Problems sessions: classes in which the problem teacher explains to the students how the standard problems of the subject are solved. The teacher will resolve in detail a list of selected problems and will propose to the students a list of problems that must be delivered as a mandatory task that will be part of the evaluation of the subject.

Discussion classes: discussion of selected readings (scientific articles) in direct relation to the topic of the subject will be evaluated with a presentation in class.

Laboratory practices: Students will perform laboratory practices as a learning tool.

Supervised training activities:

Tutorials: in the hours of attention to the students, the teachers will be available for the consultations of the students.

Autonomous training activities:

Problem-solving and delivery of additional problems: the student must solve the problems of the list given by the teachers. Some selected problems will be required to be delivered and will be evaluated by the professor.

Studyand preparation of exams: Personal work of the student to acquire the theoretical concepts of the subject and the abilities for the resolution of problems.

Works: students will be asked to generate a small report, in certain thematics that complement the contents of the subject. The derived marks will be part of the evaluation.

If the health situation requires a reduced attendance:

-Master sessions will be uploaded in video format, and discussed online in tutorial sessions in the scheduled hours.
-On-site sessions will be used essentially to solve problems, and to the realization of specific tutorials on the theoretical material previously supplied.
-The assistance to laboratory practices will be addapted to follow health considerations.

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
Continuous Assessment: Practices, problems, reports	30%	34	1.36	CM18, CM19, CM21, KM32, KM36, SM30
EXAMS	70%	9	0.36	CM19, KM32, KM36, SM30

The subject will consider different types of assessment activities.

- Partial exams: Several synthesis tests will be done where the theoretical knowledge of each thematic block will be evaluated. These partial test will be programmed throughout the semester taking profit of the preset schedule for partial test. The total weight of each partials on the final mark will be 70%. If any of the partial exams does not reach the mark of 4 out of 10, it will have to be compensated in a final evaluation.

The relative weight of each partial exam will be decided based on the academic course and contents considered, but in all the cases any partial exam will exceed more than 50% of the final mark.

- Continuous and practical evaluation activities. During the course there will be different activities of continuous evaluation that will have a weight of 30% on the final note. These activities will include laboratory practices, writing reports, monographic works, presentations and delivery of problems.

Recovery. There will be a final exam of recovery where students can be examined from the parts of the suspended partials. In order to be able to get benefit from the recovery exam, the student should have participated in at least a minimum of 2/3 of the evaluation activities of the complete subject. Continuous evaluation activities are intended to evaluate the daily follow-up of the subject and therefore, as in the case of laboratory practices, they can not be recovered.

Depending on health scenario the evaluation will be adapted.

Unique Evaluation.

Theoretical Exams (70%)

Students who have opted for the unique evaluation method will have to take a final test that will consist of an exam on the content covered in the different partial exams throughout the course. This exam will account for 70% of the final grade (equivalent to the weight of the partial exams in regular evaluation) and will be scheduled on the date of the second partial exam, with an extended timeframe. If the score on this exam is below 4 out of 10, the student will have to take a recovery exam.

Practical Assignments (15%) and Continuous Assessment Tasks (15%)

Students who have chosen the unique evaluation method must complete the mandatory practical assignments, which account for 15% of the final grade. One or more practice groups will be designated exclusively for students under the unique evaluation method. These students must complete the practical assignments in-person during the first or second scheduled session. The reports for both assignments will be submitted individually on the same day as the exam (scheduled for the second partial). Additionally, on the same day, students will submit individual tasks solving a set of selected problems, accounting for 5% of the grade, and an individual presentation of a scientific article related to the subject recorded on video, accounting for 10% of the grade. The practical assignments and task submissions are not recoverable.

Bibliography

The physics of low-dimensional semiconductors. J. H. Davies. Cambridge University Press. 1998.

Electronic transport in mesoscopic systems, S. Datta, Cambridge University Press, 1995.

Nanoscale energy transport and conversion : a parallel treatment of electrons, molecules, phonons, and photons. G. Chen, Oxford University Press, 2005.

Software

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Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

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