Bachelor in Physics
(Academic Year 2021-22)

Solid State Physics		Code	800515	Year	3rd	Sem.	2nd
Module	General Core	Topic	Quantum physics and statistics	Character	Obligatory		

	Total	Theory	Exercises
ECTS Credits	6	3.5	2.5
Semester hours	54	29	25

Teaching Coordinator:	Miguel Ángel González Barrio		Dept:	FM
	Office:	116	e-mail	mabarrio@fis.ucm.es

Theory/Practicals/Seminars - Lecturer and timetable details

Group	Room	Day	Timetable	Lecturer	Period/ Dates	Hours	T/P/S*	Dept.
B	8	Tu Th	15:00-17:00 14:30-16:30	Fernando Sols Lucia Charles E. Creffield	Dates will be alternated throughout the semester	36 18	T/P	FM

*: T: theory, P: practicals, S: seminars

Tutorials - Lecturer and timetable details

Group	Professor	Timetable	e-mail	Place
B	Fernando 800514 Lucia	Mo, We, Fr: 11:00-13:00.	f.sols@fis.ucm.es	Office 108 2nd floor
B	Charles E. Creffield	Mo, We, Fr: 15:00-16:00 +3h telematic	c.creffield@fis.ucm.es	Office 106 2nd floor

Objetives of the course

- To understand the relationship between structure, bonding type, and the properties of solids.
- Assimilate the fundamental role played by electronic structure and its influence on transport properties.
- Understand vibration phenomena in crystal lattices and the models involved in their description.
- Understand the emergence of cooperative phenomena such as ferromagnetism and superconductivity.

Brief description of the content

Crystals, diffraction; bonding energy; vibrations in crystal lattices; electrons in solids, periodic potentials, and energy bands; cooperative phenomena in solids.

Essential previous courses

Quantum Physics 1 and Statistical Physics.

Course programme

1. Crystal structures. Crystalline and amorphous solids. Crystal structures. Monocrystals and polycrystals. Symmetries. Bravais lattices: centered lattices. Diffraction. Reciprocal lattice. Structure factor. Brillouin zones.

2. Crystal bond. Binding energy. Van der Waals bond. Repulsion energy. Ionic bond. Concepts of covalent bond and metallic bond.

3. Lattice vibrations. Adiabatic approximation. Harmonic potential. Vibrations in linear lattices. Acoustic and optical branches. Quantization of vibrations: phonons. Phonon spectroscopies: neutrons and Raman. Phonon density of states. Thermal properties in a lattice and specific heat.

4. Electrons in solids. Single electron approximation: momentum space. Energy bands. Fermi surface. Free electron model. Nearly-free electron models. Tight-binding approximation. Types of solids according to band structure. Electron dynamics: effective mass. Electrons and holes. Electric resistivity. Semiconductors.

5. Introduction to cooperative phenomena. Electron gas: plasmons. Ferro- and antiferromagnetism: Exchange interaction, spin waves. Superconductivity: phenomenology and basic notions, London equation, high-temperature superconductors.

Bibliography

- N.W. Ashcroft & N.D. Mermin, *Solid State Physics* (Thomson Press, India 2003)
- H. Ibach y H. Lüth , *Solid State Physics* (Springer, Berlin 1993)
- C. Kittel, Introduction to Solid State Physics 8th Edition (Wiley, New York 2005).

Internet resources

Methodology

On-campus teaching 100% (Scenario 0)

The following educational activities will be performed:

- Theory lectures where the main concepts of the subject are explained.
- Practical problem-solving lessons and supervised activities.

Semi-online teaching (Scenario 1)

Partially in-person teaching will be adapted to the general UCM indications according to the relevant health situation, for example by dividing through each group into subgroups that will alternate between in-person and telematic attendance (e.g. choosing modality A, B, or a mode suggested by the circumstances).

Each teacher will decide the way to organize his/her group with respect to partially in-person teaching, as well as the evaluation activities. Teachers will inform their groups about the most suitable procedure for online attendance to the course, ensuring that lectures and relevant materials can be followed partially online, either synchronously or not, according to the technical circumstances of each classroom or the criterion of each professor. This methodology will be continuously reviewed and will be adapted to the particular teaching needs of each group.

Online teaching (Scenario 2)
Online teaching will be adapted as much as possible to the indications of the UCM, according to the relevant health situation at the time. Each teacher will decide how to organize the activities of their group for online teaching, as well as the evaluation activities. Teachers will publicize the appropriate procedure for following the teaching online, through the Campus Virtual for example. The relevant classes or materials will be prepared for online learning, which may include procedures such as streaming the classes synchronously, making the classes available for viewing asynchronously, or others, at the discretion of each teacher. This methodology will be continuously evaluated and adapted to the particular teaching needs of each group.

Evaluation		
Examinations	**Weight:**	75%
A final examination will be given, which will be graded between 1 and 10. In addition, one or two voluntary partial exams could be given, liberatory for the final exam. These partial exams will normally take place in class hours. In case they be held out of the class schedule, students will be warned well in advance, and special care will be taken for all the students be able to take these patial exams.		
Other forms of evaluation	**Weight:**	25%
The professor may propose a number of activities that will be graded between 1 and 10. The score obtained will be kept until the final exam of the extraordinary call. Problem sets will be issued for the students to solve and upload to the Campus Virtual.		
Final classification		
For in-person or partially in-person teaching, the final grade CF will be given by the formula: $CF = \max\{0.25*A + 0.75*E, E\}$ where E is the final exam score and A the final score of other activities. In scenario 2 (fully online): Both the evaluation and the relative weights of the continuous evaluation and the final exam will adapted, according to the criteria of each lecturer, to the online methodology followed and to the demands of the health situation. Professors will inform each group as they see appropriate, e.g. through the Campus Virtual.		