SOLID STATE PHYSICS

Master in Sustainable Materials

CONTACT INFORMATION

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COURSE CONTENT AND INTENDED LEARNING OUTCOMES (ILOs):

The Solid State Physics course is the basis to understand the main properties of materials: for sake of complexity in the mathematical tools, we focus of infinite, periodic and perfect crystals. A first part of the course is devoted to the treatment of simpler phenomena, as described in terms of non-interacting particles (electrons or phonons). The second part analyzes more complex phenomena, generated by the interaction among particles, which give rise to significant macroscopic properties of the perfect and infinite solid.

At the end of the course, the student will be able to

- use the solid state theory methods and tools to derive microscopic determination of macroscopic properties
- use the relations between crystal structure/composition and the most important properties and effects in solids to design specific material features

Aligning with the EIT OLOs:

1 = peripherally relevant to the course content; 2 = highly relevant to course content.

- ☐ EIT OLO 1 - Making value judgments and sustainability competencies
- ☐ EIT OLO 2 - Entrepreneurship skills and competencies
- ☑ EIT OLO 3 - Creativity skills and competencies - 2
- ☐ EIT OLO 4 - Innovation skills and competencies
- ☑ EIT OLO 5 - Research skills and competencies - 2
- ☐ EIT OLO 6 - Intellectual transforming skills and competencies
- ☐ EIT OLO 7 - Leadership skills and competencies

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

Description of how the course covers the EIT OLO(s) and EIT Thematic Areas

Particular attention is paid in teaching theoretical skills which can be used as a general tool for developing analytical models, allowing the students to approach complicated problems by ingenious simplifications (**OLO 3**). In the second part of the course, the focus is placed on the understanding of non-intuitive concepts and the ideal line of reasoning, preferring - also here - the methodological approach rather than the taxonomic one. The complementation of a main text with several others, depending on the topic, is an important aspect of the teaching method, that is, to acquire the habit of consulting different sources and comparing them critically, as in a typical research context (**OLO 5**). Applications to sustainability enter via thermal and thermo-electric phenomena, and superconductivity as a propaedeutic part of **EIT Thematic Area No. 6**: "Design of products and services for circular economy".

ASSESSMENT METHODS AND GRADING SYSTEM

The assessment method is based on three steps: in the first one we test how much the student is skilled in using the solid state theory methods and tools to derive microscopic determination of macroscopic properties (**OLO 3**); in a second step we test the skills in using the relations between crystal structure/composition and the most important properties and effects in solids to design specific material features for applications (**OLO 5**). In a third part we test the qualitative understanding of more complex phenomena, involving electron correlations, as for Ferromagnetism and Superconductivity.

Our assessment method is oriented to test the capability of the students in managing concepts and methods which are necessary to conceive, develop and characterize new materials and new systems. It is mainly devoted to students willing to continue a research curriculum in academic or industrial environments.

The grades in the Italian university system are expressed out of **30.** The passing grade is **18/30**.
Here below is the breakdown of the final grade:

ASSESSMENT METHOD	WEIGHT ON FINAL GRADE
Class participation	10%
Lab / on-the-field task	0%
Written output(s) (essay, position papers, case study, final exam etc.)	40%
Oral exam	50%

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COURSE SESSIONS

Suggested pre-course reading materials: a Course in Quantum Mechanics, available in the curriculum

Session 1	ANY LESSON OF THE COURSE
Content	• Introduction to the subject with one outiline of the topics • Treatment of the topics with full description of derivations • Figures reporting data and graphical sketches of phenomena • Synthetic biographical data of historically relevant scientists
Readings	The slides, available to the students before the Lesson, are self-contained and all the sources, mainly the textbook, but not only, are provided in the slides
Assignment	Once per week a collective discussion with students, in order to reply to the questions, is organized, plus individual tutoring on request. The participation is solicitaded, still not compulsory.

COPY THE ABOVE TABLE FOR THE NEXT SESSIONS.

Session 6	FINAL EXAM
Date - hours	January, February, April, June, July, September, November
Content	We organized two modalities. Three partial tests during the Course, as composed by one written part and a short oral part for the first two partials, one oral (longer) test for the third partial. Otherwise, after the conclusion of the Course, two partials: one with a written part and a shorter oral part, corresponding to the contents of the first part of the Course, the second with a longer oral test on the second part of the Course.

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