2SC5510 – Physics of matter

Instructors: Hichem Dammak
Department: DÉPARTEMENT PHYSIQUE
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 34,50

Description

The course aims to provide students with the basic knowledge of solid-state physics. Using specific examples from advanced sectors, such as nanosciences or optoelectronics, the goal is:
- to introduce them to this vast and rich physics field,
- give them the tools that will allow them to confront with confidence the many challenges that this field will bring to tomorrow's applications.

Quarter number

ST5

Prerequisites (in terms of CS courses)

Quantum Physics course
Statistical Physics course
Electromagnetism in vaccum

Syllabus

Course syllabus:
- Order in solids: the crystal lattice.
- Scattering of waves by the crystals: diffraction.
- Phonons and thermal properties.
- Metals and conductivity: Drude and Sommerfeld models.
- Band structure: electrons in bulk crystals and in nanostructures.
- Semiconductors – Quantum wells: applications in optoelectronics.
- P-N junction (diode)

Class components (lecture, labs, etc.)

Lectures (15 hours), tutorials (18 hours).

Grading

Final exam (FE): Written exam (1h30) without documents with a provided form.
Continuous assessment (CA) : 3 Quizzes of 10 minutes at the beginning of a class session
Final grade: FG=0.35 CA + 0.65 FE
Grade Session 1: Max(FG,FE)

Validation of the C1 skill: Score in one of the two indicated exercises of the final exam is higher or equal to 50%.
Validation of the C2 skill: The mark of the session 1 is higher or equal to 50%.

Session 2:
Written exam (1h30) without documents with a provided form. The grade of session 2 will not take into account the CC mark.

Course support, bibliography

Handout
Solid-state physics, Ashcroft and Mermin
Solid-state physics, Kittel

Resources

Teaching staff: H. Dammak, B. Dkhil, J.M. Gillet and C. Paillard

Learning outcomes covered on the course

At the end of the course, students are expected to know:
1) Determine the crystal system and Bravais lattice of a crystal and specify the lattice multiplicity chosen from a geometric data of a lattice of atoms.
2) Express the inter-reticular distances using Miller indices.
3) Apply Bragg's law to analyze the results of a diffraction experiment using X-rays, neutrons or electrons.
4) Identify, among the phonon dispersion relation curves along a direction of the reciprocal lattice, the optical, longitudinal acoustic and transverse acoustic branches as well as its degeneracy.
5) Determine the density of phonon states in the Debye model in 1D, 2D or 3D.
6) Calculate the contribution of phonons to the specific heat using the Debye model.
7) Apply the free electron model to determine the electronic states in a quantum well in 1D or 2D.
8) Apply the free electron model to calculate the density of electronic states and the Fermi energy.

9) Apply the free electron model to determine the contribution of electrons to the specific heat.
10) Identify, from the electron energy dispersion relations, the metallic, insulating or semiconducting character of a crystal.
11) Determine the carrier density in an intrinsic or doped semiconductor from a model of the valence and conduction band electron density curves.
12) Describe the equilibrium of a P-N junction (diode).

Description of the skills acquired at the end of the course

C1.2: Modeling: use and develop appropriate models, choose the right scale of modeling and relevant simplifying assumptions (outcomes 5-9)
C1.3: Apply problem-solving through approximation, simulation and experimentation (outcomes 1-4,10-12)
C2.1: Deepen your knowledge of an engineering field or scientific discipline