UCL Université catholique de Louvain

LMAPR1492

2012-2013

Materials physics

5.0 credits	37.5 h + 22.5 h	2q

Teacher(s) :	Charlier Jean-Christophe ; Gonze Xavier ; Piraux Luc ; Rignanese Gian-Marco (coordinator) ;
Language :	Français
Place of the course	Louvain-la-Neuve
Prerequisites :	LMAPR1491 Statistical and quantum physics LMAPR1805 Introduction to materials science
Main themes :	The covered topics include : geometric and structural crystallography, basics of X-ray crystallography, Born-Oppenheimer and independent electron approximations, electronic band structures and its simple models, phonons and anharmonic effects, semiconductors, magnetism, some transport properties.
Aims :	This module presents the basics of material physics (particularly periodic solids). At the end of the module, the students master the simple models of solids, and understand their electronic, dynamic, thermodynamic, magnetic and transport properties (transport of charge and heat). *The contribution of this Teaching Unit to the development and command of the skills and learning outcomes of the programme(s) can be accessed at the end of this sheet, in the section entitled "Programmes/courses offering this Teaching Unit".*
Teaching methods :	Ex-cathedra lectures, exercises, laboratory.
Content :	1. Geometric crystallography(point lattice; lattice systems ; lattice symmetry ; point symmetry ; space symmetry ; lattice plane ; reciprocal lattice ; Brillouin zone) 2. Structural crystallography(binding strength ; rare-gas crystals ; ionic crystals ; covalent crystals ; metallic crystals ; hydrogen-bonded crystals) 3. Basics of X-ray crystallography 4. Born-Oppenheimer approximation and independent electron approximation(splitting of the dynamics of nuclei and electrons, screening, exchange and correlation effects) 5. Periodic potential and band structure.(review of crystallography and symmetry, reciprocal space, Brillouin zone, Bloch theorem, density of states, Fermi surface, metals, insulators) 6. Nearly-free electron approximation(Born-Von Karman method, folding of the free electron parabola in the first Brillouin zone, Bragg reflections, gap opening, sodium, magnesium, aluminum) 7. Tight-binding approximation(monoatomic linear chain, s-p bonding in semiconductors and carbon compounds, d bonding in transition metals, ionic compounds) 8. Nuclei dynamics(harmonic approximation; dynamical matrix; normal modes of vibration ; phonon band structure, monoatomic and diatomic chain, acoustic and optic modes, transverse and longitudinal modes, examples of phonon band structures for different solids) 9. The free electron gas(occupation of states, Fermi vector and energy as a function of the density, electronic specific heat, thermodynamical functions, comparison with the lattice specific heat) 10. Semiconductors(impurity levels, computation of electron and hole densities, Fermi level position) 11. Dynamics of electrons in the periodic solid(carrier speed, electric and magnetic field effects in metals, effective mass, current in bands : electrons and holes) 12. Transport and anharmonic effects(diffusion processes for electrons and Boltzmann equation, metallic electric conductivity, anharmonicity and thermal expansion, diffusion process for phonons and heat conduction, electron-phonon collisions in metals; Hall effect) 13. Magnetism(introduction and overview of magnetic properties ; paramagnetism of the free electron gas ; band model of ferromagnetism) 14. Superconductivity(introduction : experimental characteristics and theoretical approaches)
Cycle and year of study :	> Bachelor in Engineering > Bachelor in Engineering
Faculty or entity in charge:	FYKI