

Teacher(s)	Charlier Jean-Christophe ;Gonze Xavier ;Poncé Samuel ;
Language :	French
Place of the course	Louvain-la-Neuve
Prerequisites	This course assumes knowledge of: - The concepts of statistical physics, basic quantum physics, and solid-state physics as taught in course LFYKI1102 (Statistical Physics and Solid-State Physics I) or equivalent course.
Main themes	Quantum physics : the course reviews the postulates of nonrelativistic quantum mechanics, measurement theory, Heisenberg's uncertainty principle, the hydrogen atom, polyelectronic atoms, the spin, the variational principle, and the matrix mechanics. Solid State Physics II : the course presents advanced concepts in solid state physics—independent/quasi-free electron approximations, electron dynamics in solids, electron band diagrams, vibrations in solids (anharmonicity), magnetism, and various charge and heat transport phenomena, basics of both superconductivity and spintronics.
Learning outcomes	At the end of this learning unit, the student is able to : Contribution of the course to the program's learning outcomes With regard to the learning outcomes of the « Bachelor of Engineering Sciences within the Civil Engineering program », this course contributes to the development and acquisition of the following learning outcomes: • Axis No. 1: knowledge of fundamental and polytechnic sciences: 1.1 • Axis No. 2: 2.3, 2.6, 2.7 Learning outcomes specific to the course At the end of this course, students will be able to: • explain the basic postulates and equations of non-relativistic quantum physics; • apply quantum physics to the treatment of various simple systems; • calculate the average values of simple observables for single-electron wave functions, their fluctuations, verify Heisenberg's uncertainty principle, and construct the matrix representation of an operator; • compare the electronic properties of metals and semiconductors, assess the effect of doping in the latter, and introduce basic semiconductor devices; • discuss the effects of external fields (electric and magnetic) on electronic properties; • understand the thermal and magnetic properties of materials; • explain the phenomena of electrical and thermal transport in crystalline solids ; • understand the basics of superconductivity and spintronics.
Evaluation methods	Students are assessed individually in writing on the basis of the specific objectives announced in advance (questions relating to their knowledge, understanding, and ability to apply the concepts covered in the course, the latter being developed during the practical sessions).
Teaching methods	Lectures and practical learning sessions (tutorials) are held in parallel to enable students to apply the theoretical concepts presented in a more concrete manner.
Content	1. Quantum physics 1.1. Postulates and operator concepts 1.2. Heisenberg's uncertainty principle 1.3. The hydrogen atom and polyelectronic atoms 1.4. Periodic table of elements 1.5. Matrix mechanics 1.6. Strong coupling method 2. Electrons in solids 2.1. Approximations of independent electrons (screening effect, exchange and correlation effects). 2.2. Periodic potential (Bloch's theorem, density of states, Fermi surface) 2.3. Quasi-free electron approximation (Born-Von Karman method, folding of the free electron parabola in the first Brillouin zone, Bragg reflections, gap opening) 2.4. Dynamics of electrons in periodic solids (equations of motion, effects of electric and magnetic fields, effective mass, electron and hole currents in bands)

	2.5. Semiconductors (band diagrams, free carrier concentrations, doping and impurity levels, devices: p-n junction, LED, transistor, photovoltaic) 2.6. Superconductivity (Cooper pairs, BCS theory, etc.) 3. Vibrations in solids 3.1. Review of the linear atomic chain (harmonic approximation). 3.2. Anharmonicity effects (thermal expansion) 3.3. Thermal conductivity 4. Properties 4.1. Spin 4.2. Ising model 4.3. Paramagnetism of free electron gas 4.4. Band model of ferromagnetism 4.5. Concepts of spintronics
Bibliography	Plusieurs livres basés sur la thématique de la physique quantique et de l'état solide sont disponibles en bibliothèque
Faculty or entity in charge	FYKI

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Minor in Applied Chemistry and Physics	MINOFYKI	5		
Specialization track in Applied Chemistry and Physics	FILFYKI	5		
Master [120] in Energy Engineering	NRGY2M	5		
Mineure Polytechnique	MINPOLY	5		