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6.00 credits	45.0 h + 30.0 h	Q2
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Language :	French > English-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	It is recommended that students master the notions of Hamiltonian mechanics as developed in course LMAT1261, of thermodynamics as developed in course LPHYS1114 and the basics of quantum mechanics as developed in course LPHYS1241.
Main themes	This teaching unit is an introduction to the concepts and methods of statistical physics at equilibrium and out of equilibrium.
Learning outcomes	<p><b>At the end of this learning unit, the student is able to :</b></p> <p><b>a. Contribution of the teaching unit to the learning outcomes of the programme</b> 1.1, 1.3, 1.4, 2.1, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6</p> <p><b>b. Specific learning outcomes of the teaching unit</b></p> <p>At the end of this teaching unit, the student will be able to :</p> <ol style="list-style-type: none"> <li>describe macroscopic systems by the probabilistic methods of statistical physics within the framework of microcanonical, canonical and grandcanonical ensembles, and derive their macroscopic / thermodynamic laws;</li> <li>treat interacting particle systems by the mean field approximation;</li> <li>understand the effect of quantum statistics on the physics of fermion and boson systems;</li> <li>analyse the evolution of a system towards equilibrium by the master equation; describe elementary transport phenomena.</li> </ol>
Evaluation methods	The evaluation is based on a written exam. It deals with the fundamental concepts of statistical physics and their applications to problems of atomic physics, solid-state and condensed matter physics etc. It tests the student's knowledge and the understanding of theoretical concepts, the student's ability to analyse the physics of a macroscopic system via the formalism of the statistical physics as well as the coherent presentation of this analysis.
Teaching methods	The learning activities consist of lectures and exercise sessions. The lectures are intended to introduce the fundamental concepts of statistical physics and, by establishing results, to show their reciprocal links and their relations with other teaching units of the Bachelor's programme in physics. The exercise sessions present the wide range of applications of statistical physics, allow the student to become acquainted with the formalism of statistical physics and interpret its predictions.
Content	<p>The objective of statistical physics is to determine the laws of physics of macroscopic systems from the fundamental laws of their microscopic constituents by probabilistic methods. This teaching unit provides an introduction to this approach for systems at equilibrium and out of equilibrium.</p> <p>The course will cover a selection of the following topics :</p> <ol style="list-style-type: none"> <li><b>Reminder of thermodynamics:</b> thermodynamic description of macroscopic systems, first and second law, thermodynamic potentials, equations of state.</li> <li><b>The foundations of statistical physics:</b> probability reminders, micro- and macro-states, counting states and density of states, statistical entropy, fundamental postulate and the microcanonical, relaxation of constraints and thermodynamic quantities.</li> <li><b>The canonical ensemble:</b> coupling to a heat reservoir and the Gibbs law, the equivalence of ensembles, applications (kinetic theory, perfect polyatomic and molecular gases, the thermodynamics of oscillators and the Debye model, black-body radiation).</li> <li><b>Systems of interacting particles :</b> liquid-gas transition (Mayer and cumulative expansion, the van der Waals equation, Maxwell's construction), paramagnetic-ferromagnetic transition (microscopic origin of magnetism, Heisenberg and Ising model, transfer matrices), mean field theory.</li> <li><b>The grandcanonical ensemble and quantum statistics:</b> coupling to a particle reservoir, Fermi-Dirac and Bose-Einstein statistics, the degenerate Fermi gas, Bose-Einstein condensation, applications (semiconductors, neutron star, helium-3 and helium-4).</li> </ol>

Inline resources	The MoodleUCL website of this teaching unit contains a detailed plan of the covered content, a complete bibliography, exercise sheets and a collection of exam subjects from past years.
Bibliography	<ul style="list-style-type: none"> <li>• B. Diu, C. Guthmann, D. Lederer, B. Roulet , <i>Éléments de physique statistique</i>. Hermann (2001).</li> <li>• M. Kardar, <i>Statistical physics of particles</i>. Cambridge University Press (2007).</li> <li>• H. Krivine, J. Treiner, <i>La physique statistique en exercices</i>. Vuibert (2008).</li> <li>• F. Reif, <i>Fundamentals of thermal and statistical physics</i>. Waveland Inc (2008).</li> <li>• C. Texier, G. Roux, <i>Physique statistique. Des processus élémentaires aux phénomènes collectifs</i>. Dunod (2017).</li> </ul>
Faculty or entity in charge	PHYS

<b>Programmes containing this learning unit (UE)</b>				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Minor in Physics	<a href="#">MINPHYS</a>	6		
Bachelor in Physics	<a href="#">PHYS1BA</a>	6		
Master [120] of Education, Section 4 : Physics	<a href="#">PHYS2M4</a>	6		