


 Faculty of Applied Sciences

**MAPR2492 Materials physics**

[37.5h+22.5h exercises] 5 credits

This course is taught in the 2nd semester

**Teacher(s):** Vincent Bayot, Patrick Bertrand, Jean-Christophe Charlier, Xavier Gonze (coord.), Luc Piraux  
**Language:** French  
**Level:** Second cycle

**Aims**

This lecture presents the basics of materials physics (particularly the periodic solids). It is the logical continuation of the lecture MAPR 2110 and, with the lecture ELEC 2330, the basis of the formation in the module 30.02.

**Main themes**

Introduction of the basis notions that allow the understanding of periodic solids : structural, electronic, vibrational, magnetic, optical, thermodynamical and transport properties. Provided it is adequate, the study of molecule is also done.

**Content and teaching methods**

Lectures " ex cathedra " : presentation of the concepts

Exercices, in view of a better understanding of the subject.

## I. Born-Oppenheimer approximation

(decoupling of electron and ion dynamics, study of energy levels of diatomic molecules)

## II. Interacting electrons

(independent electron approximation ; exchange-correlation effects ; combination of angular momenta, with applications to atoms and polyelectronic molecules)

## III. Point symmetries and spatial symmetries

(32 point symmetry groups ; group theory ; electronic structure of molecules ; review of crystallographic concepts ; spatial groups of symmetry : frequent crystalline structures)

## IV. Band theory

(periodic potential ; Brillouin Zone ; Bloch theorem ; tight-binding approximation ; Sommerfeld model ; density of states ; Fermi surface and Fermi energy ; approximation of quasi-free electrons)

## V. Magnetic properties

(diamagnetism, paramagnetism and ferromagnetism ; magnetic properties of a free electron gas ; band ferromagnetism)

## VI. Dynamics of nuclei

(harmonic approximation ; vibration modes of molecules ; phonons ; acoustic modes and elastic constants : optical modes in ionic crystals ; thermodynamic properties)

## VII. Dynamics of electrons

(electrical conductivity ; Boltzmann transport equation ; electron-phonon interaction ; Hall effect ; electronic thermal conductivity)

## VIII. Anharmonic effects

(thermal expansion ; lattice thermal conductivity)

## IX. Spectroscopies and optical properties

(review of time-dependent perturbation theory : selection rules : classification of spectroscopies : interaction between an electric field and matter : optical phenomena due to vibrations : optical phenomena due to electronic excitations).

## X. Superconductivity

(experimental facts ; phenomenological theories)

**Other information (prerequisite, evaluation (assessment methods), course materials recommended readings, ...)**

MAPR 2110 Introduction to materials physics

**Other credits in programs**

<b>MAP22</b>	Deuxième année du programme conduisant au grade d'ingénieur civil en mathématiques appliquées	(5 credits)	
<b>MATR21</b>	Première année du programme conduisant au grade d'ingénieur civil en science des matériaux	(5 credits)	Mandatory