Course Package

Science

Name module	Science
Educational programme	BSc Advanced Technology
Period	First quartile of the first semester (Quarter 1A)
Study load	15 ECTS
Coordinator	E.M. Marsman

Science			
Quarter 1A	**Quarter 1B**	**Quarter 2A**	**Quarter 2B**
Introduction Solid State Physics (5 EC)			
Statistical Physics (5 EC)			
Optics (2,5 EC) **Molecular Structure and Spectroscopy** (2,5 EC)			

Required preliminary knowledge: Basic Quantum Mechanics.

This module gives a further introduction into modern physics and chemistry of (nano)matter. Combining statistical physics and solid state physics, the properties of atoms, molecules and crystalline solids are derived. The module consists of 4 parts: Statistical Physics, Introduction to Solid State Physics, Molecule Spectroscopy and Optics. The content of the four parts is:

Statistical Physics
The focus is on the relation between the atomic composition of a system (atoms in perpetual motion) and the ensuing macroscopic behavior (pressure, temperature, etc). Statistical descriptions are introduced to describe systems of 1E23 atoms in terms of partition functions, and their relations to thermodynamic potentials are discussed. The main topics include statistical definitions of entropy, internal energy and Helmholtz free energy, the Boltzmann distribution, Fermi-Dirac and Bose-Einstein distributions, the fundamental assumption of statistical mechanics, the equipartition theorem, equations of state. These concepts are applied to various simple systems, like ideal and non-ideal gases, solids and liquid mixtures.

Introduction Solid State Physics
A crystalline material is described by its periodic lattice. The associated reciprocal space lattice is introduced and related to the characterization of a crystalline material with X-ray diffraction. The influence of lattice dynamics on macroscopic properties is treated in terms of phonons and dispersion relations. Bose-Einstein distribution is used to evaluate the contribution of lattice dynamics to the heat capacity. The description of

electron distribution in a material starts from the free electron model and with the aid of the reciprocal lattice the nearly free electron model is introduced. The concept of effective mass and Fermi-Dirac distribution are explained and several macroscopic features such as electron contribution to heat capacity and conductivity are treated.

Molecule structure and spectroscopy

This part extends the knowledge introduced in the first year quantum mechanics course and discusses the theory behind chemical bonding, as well as spectroscopic characterization. Topics being addressed involve the valence bond theory, hybridization of orbitals, molecular orbital theory, bonding and antibonding orbitals, electronic structures of molecules, introduction spectroscopy, vibrational transitions, rotational transitions and nuclear magnetic resonance.

Optics

In this part we address the basic concepts of both geometrical optics (light as a ray) and physical optics (light as a wave). The course consists of a few lectures and a larger experimental assignment. In the lectures the theoretical concepts will be discussed, while in the experimental assignment the student will apply these concepts to design, construct and characterize an optical instrument (e.g. microscope and/or photo-spectrometer). The instrument is then used to carry out experiments that relate to microscopic/spectroscopic characterization of materials.

The modules are tentative and subject to change. Please check the website regularly.