University of L'Aquila

Department of Physical and Chemical Sciences

Bachelor-level course in Chemical and Materials Sciences and Technologies

Academic Year 2013-2014

Physics of Matter

Teacher: Dr. L. Lozzi

- **Elements of electromagnetism**
  - Electric and Magnetic fields
  - Maxwell equations
  - Electromagnetic waves
  - Interference and Diffraction

- **The crisis in Classical Physics: Particle-like properties of electromagnetic waves**
  - Black-body radiation, stationary waves, Rayleigh-Jeans law.
  - Quantisation of Energy and Planck theory
  - The photoelectric effect
  - The Compton effect

- **The structure of the atom**
  - The Thomson's model
  - The Rutherford's model

- **The electronic structure of the atoms**
  - The Bohr's model, quantisation of the states, correspondence principle
  - The Franck-Hertz experiment

- **Wave-like properties of particles**
  - The de Broglie wavelength
  - The wave packets
  - Wave superposition and beats
  - Bohr quantisation rules and de Broglie theory
  - The Heisenberg principle of uncertainty
  - Wave functions and probability amplitude
  - Dual nature of particles and waves

- **The Schroedinger equation**
  - The Schroedinger equation and the time independent Schroedinger equation
  - Properties of the Schroedinger equation: eigenfuctions and eigenvalues
  - Operators in quantum mechanics
  - Examples of Schroedinger equations:
    - The free particle

        - Particle in 1-D box
        - Energy quantisation
        - 2-D and 3-D potential wells
        - The simple harmonic oscillator
        - The step potential
        - Barrier potential
        - The tunneling process

- **The hydrogen atom**
    - The Schroedinger equation for one-electron atoms
    - The Schroedinger equation in spherical coordinates
    - Solutions of the Schroedinger equation for one-electron atoms.
    - Radial and angular probability densities
    - The angular momentum operators
    - Magnetic dipole for the hydrogen atom
    - Magnetic dipole-magnetic field interaction, angular momentum precessing
    - The Stern-Gerlach experiment: the electron spin
    - Transition selection rules (outlines)
    - The Zeeman effect
    - The spin-orbit interaction (outlines)

Laboratory sessions (mandatory for students of the Materials Science curriculum):

- Determination of the prism refractory index using the Cauchy's law
- Determination of the Rydberg constant using a prism and a diffraction grating
- Determination of the electron e/m ratio
- The Stefan law on black body using an I-V circuit
- The photoelectric effect: determination of the Planck constant
- The Franck-Hertz experiment

Reading list:

1. K. Krane, Modern Physics, John Wiley & Sons (main text)
2. P.A. Tipler, Corso di Fisica, vol. 3: Fisica Moderna, Zanichelli (Italian)
3. R. Eisberg, Fundamentals of Modern Physics, John Wiley & Sons
4. S. Gasiorowicz, Quantum Physics, John Wiley & Sons
5. L. Colombo, Elementi di Struttura della Materia, Hoepli (Italian)

The textbook is the first one in the reading list, the second is very similar (but in Italian, the English version: P.A.Tipler: Modern Physics, W. H. Freeman publisher). The third book has been used for some insights. The forth book is suggested only for students that would like to study in depth the quantum mechanics, but a much deeper knowledge of mathematics with respect to all the other textbooks is necessary. The last book is too simple and is suggested for understanding some details for Italian students that have problem with the English textbooks. All books are available at the Library of Coppito 1 building.