Department of Physical and Chemical Sciences

BACHELOR DEGREE IN CHEMICAL AND MATERIALS SCIENCES AND TECHNOLOGIES

PROGRAMME OF "PHYSICS OF MATTER AND LABORATORY"

A.A. 2017-2018

Teacher: Prof. Luca Lozzi; ***ECTF***: 9

- **Elements of electromagnetism**
  - Electric and Magnetic fields
  - Maxwell equations
  - Electromagnetic waves
  - Interference and Diffraction
- **Special Theory of Relativity**
  - The Galilean transformation
  - The Michelson-Morley experiment
  - Einstein's postulates
  - The Lorentz transformation
  - Relativistic dynamics
- **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:

- 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, Modern Physics, W.H. Freeman (same level of the main text)
3. F. Ciccacci, Fondamenti di Fisica Atomica e Quantistica, EdiSES (for some insights, only in Italian)
4. R. Eisberg, Fundamentals of Modern Physics, John Wiley & Sons (for some insights)
5. S. Gasiorowicz, Quantum Physics, John Wiley & Sons (only for students that want to study in depth quantum mechanics)
6. L. Colombo, Elementi di Struttura della Materia, Hoepli (only in Italian)

Assessment methods: written and oral examination