Syllabus for the course of Condensed Matter Physics
prof. Sergio Caprara

The course relies on the following prerequisites:

1. CLASSICAL MECHANICS
reference text:
H. Goldstein, C. P. Poole, and J. L. Safko
Classical Mechanics, Addison-Wesley

chapter 1 Survey of elementary principles
- mechanics of a particle
- mechanics of a system of particles
- contraints
- D'Alambert's principle and Lagrange's equations

chapter 6 Oscillations
- formulation of the problem
- the eigenvalue equation and the principal axis transformation
- frequencies of free vibration and normal coordinates

chapter 8 The Hamilton equations of motion
- Legendre transformations and the Hamilton equations of motion

chapter 9 Canonical transformations
- the equations of canonical transformations
- Poisson brackets
- Liouville's theorem

2. CLASSICAL ELECTROMAGNETISM
reference text:
D. Halliday, R. Resnick, and K. S. Crane
Physics - part II, John Wiley & sons
chapter 25 Electric charge and Coulomb's law
- electric charge
- conductors and insulators
- Coulomb's law
- continuous charge distributions
- conservation of charge

chapter 26 The electric field
- the electric field
- the electric field of point charges
- the electric field of continuous charge distributions

chapter 27 Gauss' law
- the flux of the electric field
- Gauss' law

chapter 28 Electric potential energy and potential
- electric potential energy
- electric potential
- calculating the potential from the field
- potential due to point charges
- potential due to continuous charge distributions
- calculating the field from the potential
- equipotential surfaces
- the potential of a charged conductor

chapter 29 The electric properties of materials
- types of materials
- a conductor in an alectric field
- ohmic materials
- Ohm's law
- an insultatori in an electric field

chapter 30 Capacitance
- capacitors
- capacitance

chapter 31 DC circuits
- electric current
- electromotive force

chapter 32 The magnetic field
- the magnetic force on a moving charge
- circulating charges
- the Hall effect

3. QUANTUM MECHANICS
reference text:
J. J. Sakurai
Modern Quantum Mechanics, Addison-Wesley

chapter 1 Fundamental concepts
- kets, bras, operators
- base kets and matrix representation
- measurements, observables, and uncertainty relations
- position, momentum, and translation
- wave functions in position and momentum space

chapter 2 Quantum dynamics
- time evolution and the Shroedinger equation
- the Shroedinger versus the Heisenberg picture
- simple harmonic oscillator
- Schroedinger's wave equation

chapter 3 Theory of angular momentum
- rotations and angular momentum commutation relations
- spin 1/2 systems and finite rotations
- eigenvalues and eigenstates of angular momentum
- orbital angular momentum
- addition of angular momenta

chapter 4 Symmetry in quantum mechanics
- symmetries, conservation laws, and degeneracies
- discrete symmetries, parity, or space inversion
- lattice translation as a discrete symmetry
- the time-reversal discrete symmetry

chapter 5 Approximation methods
- time independent perturbation theory: non degenerate case
- time independent perturbation theory: the degenerate case

4. STATISTICAL MECHANICS
reference text:
K. Huang
Statistical Mechanics, John Wiley & sons

chapter 6 Classical statistical mechanics
- the postulate of classical statistical mechanics
- microcanonical ensemble
- derivation of thermodynamics
- equipartition theorem
- classical ideal gas

chapter 7 Canonical ensemble and grand canonical ensemble
- canonical ensemble
- energy fluctuations in the canonical ensemble
- grand canonical ensemble
- density fluctuations in the grand canonical ensemble
- the chemical potential
- equivalence of the canonical ensemble and grand canonical ensemble

chapter 8 Quantum statistical mechanics
- the postulate of quantum statistical mechanics
- ensembles in quantum statistical mechanics
- the ideal gases: micro canonical ensemble
- the ideal gases: grand canonical ensemble

chapter 11 Fermi systems
- the equation of state of an ideal Fermi gas

chapter 12 Bose systems
- photons
- Bose-Einstein condensation

5. ATOMIC AND MOLECULAR PHYSICS
reference text:
B. H Bransden & C. J. Joachain
Physics of atoms and molecules, Longman Scientific & Technical

chapter 3 One-electron atoms
- the Scheoedinger equation for one-electron atoms
- energy levels
- the eigenfunctions of the bound states

chapter 6 Two-electron atoms
- the Scheoedinger equation for two-electron atoms
- spin wave functions and the role of the Pauli exclusion principle
- level scheme of two-electron atoms

chapter 7 Many-electron atoms
- the central field approximation
- the periodic system of the elements

chapter 9 Molecular structure
- general nature of molecular structure
- the Born-Oppenheimer separation for diatomic molecules
- electronic structure of diatomic molecules
- the structure of polyatomic molecules