Master Degree in Materials Science: Knowledge of Quantum mechanics needed to fully understand advanced physics courses.

1. The need for quantum mechanics
    - Diffraction patterns in optics
    - Diffraction patterns in crystalline solids caused by electrons
    - Atomic spectra: why discrete lines? Bohr atomic model
    - De Broglie wavelength
2. The Schrodinger equation in 1D
    - Classical energy -> (Hamiltonian operator in cartesian coordinates)
    - Kinetic-energy operator, potential energy
    - Eigenvalues and eigenstates
    - Probabilistic interpretation
    - Heisenberg principle
    - Application: particle in a box, discrete levels for small systems
3. Further applications and extension to 3D
    - Harmonic oscillator (no demonstration)
    - Separation of variables: particle in a box in 3D
    - Kinetic Energy in 3D, angular momentum
4. Hydrogen atom
    - No demonstration of angular and radial solution, only variable separation
    - n,m,l quantum numbers, degeneracy, s, p, d states, energy levels
    - Hydrogen-like systems - 1-electron ions (ex. Li++)
5. Magnetic momenta and spin
    - Coupling of a static magnetic field with a magnetic momentum; effect on hydrogen levels
    - Stern-Gerlach experiments and the need for introducing spin
    - Zeeman effect in the strong-field limit
6. Wave-matter interaction
    - Perturbation theory
    - Dipole approximation
    - Selection rules
    - Fermi golden rule
    - Adsorption/Emission
7. Many-particle hamiltonian
    - Hamiltonian of N-electron atoms: reduction to one-particle problem only if interaction neglected
8. Identical particles
    - Anti-symmetrization and Pauli Exclusion principle
    - Ground state of He atom by neglecting electron-electron interaction: wave function, singlet
    - Variational principle: application to He ground state.
9. Quantum statistics
    - Boltzmann distribution, Fermi-Dirac distribution, Bose-Einstein distribution
    - Electron gas at T->0, the concept of Fermi energy
10. Molecules
    - Hamiltonian of a molecule

- Adiabatic approximation
- H2+ molecule by LCAO (LCAO trial function bonding and antibonding)
- Rotations and vibrations of a diatomic molecule: energy levels for purely vibrational and purely rotational levels

Suggested book: S.M. Blinder, *Introduction to quantum Mechanics in Chemistry, Materials Science, Biology*

A dedicated tutor will help the students in learning such topics offering a short course. Details will be given at the beginning of the Academic Year.

For any additional information on physics pre-requisites write to Prof. Francesco Montalenti, (francesco.montalenti@unimib.it)