LEARNING MODULE DESCRIPTION

GENERAL INFORMATION

1. Module title: Quantum Mechanics I
2. USOS code: 04-S1FZ03-P02166
3. Term: Winter
4. Duration: 30 hours, 15 weeks
5. ECTS: 5 ECTS
6. Module lecturer: Thomas Vasileiadis
7. E-mail: thomas.vasileiadis@amu.edu.pl
8. Language: English

DETAILED INFORMATION

1. Module aim (aims)
    a) Knowing how the concept of quanta (e.g. Photons) entered Physics
    b) Knowing why particles of matter should exhibit wave-particle duality analogously to light
    c) Understanding how classical variables are replaced by quantum operators
    d) Being able to extract average values and standard deviations from a given wavefunction
    e) Having the ability to solve simple one-dimensional problems.
    f) Learning the quantum harmonic oscillator and understanding its significance
    g) Understanding atomic structure, and how atoms form molecules and solids
    h) Learning how the concept of spin entered quantum mechanics
    i) Being informed about applications of quantum mechanics

2. Pre-requisites in terms of knowledge, skills and social competences (where relevant)
    a) Basic knowledge of differentiation and integration
    b) Ability to communicate and study in English
    c) Basic knowledge of classical mechanics and statistical physics

READING LIST

1) **Nouredine Zettili. Quantum Mechanics, Concepts and Applications.** Second Edition. John Wiley and Sons, Ltd., Publication.
2) **DAVID J. GRIFFITHS and DARRELL F. SCHROETER. INTRODUCTION TO QUANTUM MECHANICS.** Third edition. CAMBRIDGE UNIVERSITY PRESS.
3) **Modern Physics by Raymond A Serway.** Brooks/Cole—Thomson Learning.

SYLLABUS:

Week 1: **Introductory remarks.** Replacing classical trajectories with waves of probability.
Week 2: **Photons.** The discovery of Photons: Black body radiation, photoelectric effect, wave-particle duality, Compton scattering.
Week 3: **Atoms.** The atomic stability: Rutherford scattering, Bohr atom, De Broglie hypothesis.
Week 4: **Wavefunctions.** De Broglie waves, wavefunctions, superposition principle, wavefunction normalization, square integrable functions, expectation values.
Week 5: **Quantum operators.** Eigenvalues and eigenstates, derivation of the Schrödinger equation, Hermitian quantum operators, internal products (Hilbert space), commutators, uncertainty principles.
Week 6: **Continuous versus discrete states.** The free particle versus the particle in a box. Discrete, bound states versus Continuous, free states. Summary of what we said so far.
Week 7: **Tunnelling effect.** The meaning of imaginary momentum. The step potential. Transmission through a square barrier.
Week 8: **Finite potential wells.** Solution to the 1D Schrödinger equation, number of bound states, a first example of bonding and anti-bonding states, the Dirac potential.
Week 9: **Two-level systems.** A simple quantum mechanical system with many applications.
Week 10: **Quantum harmonic oscillator 1.** Separation of variables, Hermite Polynomials, spectrum of the harmonic oscillator.
Week 11: **Quantum harmonic oscillator 2.** Creation and annihilation operators, number operator, number states, Fock states. Some basic remarks on anharmonicity (why it is important?)
Week 12: **Hydrogen atom.** Separation of variables, spherical harmonics, Laguerre polynomials. Brief remarks on higher Z atoms and the periodic table.
Week 13: **The spin.** Theory of angular momentum, Spin ½ and the Pauli Matrices.
Week 14: **Zeeman splitting and Stark effect.** The fine structure of atomic orbitals.
Week 15: **Light-matter interactions and Fermi's golden rule.**