MANGALORE UNIVERSITY
Department of Materials Science
MSc Materials Science

MSS 508: **QUANTUM MECHANICS –II** (3 Credits)

Objectives: This course introduces the students to the advanced concepts of quantum mechanics like time dependent problems, perturbation theory, scattering theory, relativistic quantum mechanics etc. if one is interested in going deeper in o the theoretical realm.

Expected course outcomes: The student is expected to gain a strong hold on some of the aspects of quantum mechanics required to be used for the theoretical treatment of modern concepts in physics.

Unit-I

Time dependent problems: Two level systems in a harmonically varying external potential. Example of spin in an external sinusoidal magnetic field. Time evolution of spin vector. The Schrodinger, Heisenberg and Interaction pictures. Equations of motion.

Time dependent perturbation theory: Perturbation expansion. Formal solution of the Schrodinger equation in a time dependent perturbing potential. Harmonic perturbation. Fermi golden rule. Atom-Radiation interaction, dipole approximation. Spontaneous decay. Einstein A and B coefficients using Fermi golden rule. 14 hours

Unit II

Time independent scattering Theory: Scattering cross section. Boundary conditions. scattering amplitude and differential cross section. Born approximation, validity, example of Yukawa potential, Rutherford scattering formula.

Method of partial waves: Motivation, Partial wave expansion, scattering amplitude, phase shifts, partial wave amplitude, differential and total cross sections for short range potentials. Optical theorem. Low and high energy scattering from a hard sphere. Low energy scattering from a potential well and bound states, scattering length. Resonance scattering and quasi-bound states. 14 hours

Unit -III

Relativistic Quantum Mechanics: The Klein-Gordon(KG) equation. Plane-wave solutions. KG equation in a electromagnetic field. Continuity equation. Limitations of KG equation and its correct interpretation. Non-relativistic reduction of KG equation. Application to two-body problem of two spinless particles in a Coulomb potential.

Dirac Equation*:* The free particle Dirac equation. Pauli-Dirac representation. Continuity equation. Plane wave solutions of the Dirac equation in the Pauli-Dirac representation, Normalisation. Dirac equation in an electromagnetic field. Non-relativistic approximation. Spin in Dirac theory, Conservation of angular momentum. Helicity. Negative energy solutions and Hole theory. Covariant formulation of Dirac equation, Gordon decomposition of vector

current. Brief discussion on application of Dirac theory to the hydrogen atom.
14 hours

References

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2. V. K. Thankappan, Quantum Mechanics, Wiley Eastern (1985).
3. P. M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw-Hill (1977).
4. R. L. Liboff, Introduction to Quantum Mechanics, Pearson Education (2003).
5. R. Shankar, Principles of Quantum Mechanics, 2^{nd} edition,Plenum US (1994).
6. A.Ghatak and S Lokanathan, QuantumMechanics: Theory and Applications, Macmillan (2004)
7. L I Schiff, Quantum Mechanics, 3rd ed. McGraw-Hill, 1968
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11. R. P. Feynman, R.B. Leighton and M.Sands, The Feynman Lectures on Physics, Vol.3, Narosa Pub. House (1992).
12. J. S. Townsend, A Modern Approach to Quantum Mechanics, 2nd ed, McGraw Hill.
13. C. Cohen-Tannoudji, B. Diu, F. Laloe, Quantum Mechanics (2 vol. set), Wiley-Interscience (1996).