SEMESTER – III

PH3C09 QUANTUM MECHANICS – II Unit

I

Time Dependent Perturbation Theory (16 hrs)

Time dependent potentials - interaction picture - time evolution operator in interaction picture - time dependent perturbation theory - Dyson series – transition probability - constant perturbation - Fermi-Golden rule - harmonic perturbation - interaction with classical radiation field - absorption and stimulated emission - electric dipole approximation - photo electric effect – energy shift and decay width - sudden and adiabatic approximation

Text Book:

1. Advanced Quantum Mechanics, J.J. Sakurai, Pearson Education (Chapter 5)
2. Quantum mechanics – V. K. Thankappan New Age Int. Pub 1996 (Chapter 8)

Unit II

Scattering (18 hrs) Asymptotic wave function and differential cross section, Born approximation, Yukawa potential, Rutherford scattering. The partial wave expansion, hard sphere scattering, S-wave scattering for the finite potential well, resonances - Ramsaur- Townsend effect

Text Book:

1. A Modern Approach to Quantum Mechanics, John S. Townsend, Viva Books Pvt Ltd, MGH (Chapter 13)**Unit III**

Relativistic Quantum Mechanics (18 hrs)

Need for relativistic wave equation - Klein-Gordon equation - Probability conservation - covariant notation - derivation of Dirac equation - conserved current representation - large and small components - approximate Hamiltonian for electrostatic problem - free particle at rest -plane wave solutions - gamma matrices - bilinear covariant – relativistic covariance of Dirac equation - angular momentum as constant of motion.

Text Book:

1. Advanced Quantum Mechanics, J.J. Sakurai, Pearson Education (Chapter 3)

Unit IV

Elements of Field Theory (20 hrs)

Euler-Lagrange equation for fields - Hamiltonian formulation – functional derivatives -conservation laws for classical field theory - Noether's theorem - Non relativistic quantum field theory - quantization rules for Bose particles, Fermi particles - relativistic quantum field theory - quantization of neutral Klein Gordon field - canonical quantization of Dirac field – plane wave expansion of field operator - positive definite Hamiltonian

Text Book:

Field Quantization, W Greiner , J Reinhardt, Springer, (Chapter 2, 3, 4 & 5)

Quantum mechanics -V.K. Thankappan, New Age Int. Publishers

Reference Books:

(In addition to books given under PH2C06, the following books are also recommended)

Quantum Field Theory, Lewis H. Ryder, Academic Publishers, Calcutta,1989

Quantum Field Theory, Claude Itzykson & Jean Bernard Zuber, MGH, 1986

Introduction to Quantum Field Theory, S.J. Chang, World Scientific, 1990

Quantum Field Theory, Franz Mandl & Graham. Shaw, Wiley 1990

PH3C10 COMPUTATIONAL PHYSICS

Unit I

Curve Fitting and Interpolation (20Hrs)

The least squares method for fitting a straight line, parabola, power and exponential curves with the help of principle of least square fit. Interpolation - Introduction to finite difference operators, Newton's forward and backward difference interpolation formulae, Lagrange’s interpolation formula, Newton's divided difference formula with error term, interpolation in two dimensions. Cubic spline interpolation end conditions. Statistical tests - Ψ^{2-} test and T-test.

Unit II

Numerical Differentiation and Integration (16 Hrs)

Numerical differentiation, errors in numerical differentiation, cubic spline method - finding maxima and minima of a tabulated function - Integration of a function with Trapezoidal Rule, Simpson's 1/3 and 3/8 Rule and error associated with each. Romberg's integration, Gaussian integration method, Monte Carlo evaluation of integrals - numerical double integration

Unit III

Numerical Solution of Ordinary Differential Equations (20Hrs)

Euler method - modified Euler method and Runge - Kutta 4^{th} order methods - adaptive step size R-K method, predictor - corrector methods - Milne's method, Adam-Mouton method.

Numerical Solution of System of Equations

Gauss-Jordan elimination Method, Gauss-Seidel iteration method, Gauss elimination method and Gauss-Jordan method to find inverse of a matrix. Power method and Jacobi's method to solve eigenvalue problems.

Unit IV

Numerical solutions of partial differential equations (16Hrs)

Elementary ideas and basic concepts in finite difference method, Schmidt Method, Crank - Nicholson method, Weighted average implicit method. Concept of stability.

Text Books:

Mathematical Methods, G. Shanker Rao, K. Keshava Reddy, I.K. International Publishing House, Pvt. Ltd.

Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.

Reference Books:

An Introduction to Computational Physics, Tao Pang, Cambridge University Press

Numerical methods for scientific and Engineering computation M.K Jain,S.R.K Iyengar, R.K. Jain, New Age International Publishers

Computer Oriented Numerical Methods, V. Rajaraman, PHI, 2004.

Numerical Methods, E. Balagurusami, Tata McGraw Hill, 2009.

Numerical Mathematical Analysis, J.B. Scarborough, 4^{th} Edn, 1958

PH3P03 COMPUTATIONAL PHYSICS PRACTICALS

(Minimum of 12 Experiments should be done with C++ as the programming language)

Study the motion of a spherical body falling through a viscous medium and observe the changes in critical velocity with radius, viscosity of the medium.

Study the path of a projectile for different angles of projection. From graph find the variation in range and maximum height with angle of projection.

StudygraphicallythevariationofmagneticfieldB(T)with critical temperature in superconductivity using the relationship $B(T) = B_0 [1 - (T/T_c)^2]$, for different substances.

Discuss the charging /discharging of a capacitor through an inductor and resistor, by plotting time –charge graphs for a) non oscillatory, b) critical) oscillatory charging.

Analyze a Wheatstone's bridge with three known resistances. Find the voltage across the galvanometer when the bridge is balanced.

6. Study the variation inphase relation between applied voltage and current of a series L.C.R circuit with given values of L C Find the resonant frequency and maximum current.

A set of observations of π meson disintegration is given. Fit the values to a graph based on appropriate theory and hence calculate life time τ of π mesons.

Draw graphs for radioactive disintegrations with different decay rates for different substances. Also calculate the half-life's in each case.

Half-life period of a Radium sample is 1620 years. Analytically calculate amount of radium remaining in a sample of 5gm after 1000 years.Varify your answer by plotting a graph between time of decay and amount of substance of the same sample.

Plot the trajectory of a α-particle in Rutherford scattering and ditermine the values of the impact parameter.

11. Draw the phaseplotsforthefollowingsystems.
(i) A conservative case (simple pendulum)
(ii) A dissipative case (damped pendulum)
A nonlinear case (coupled pendulums).

Two masses m_1 and m_2 are connected to each other by a spring of spring constant k and the system is made to oscillate as a two coupled pendulum. . Plot the positions of the masses as a function of time.

Plot the motion of an electron in (i) in uniform electric field perpendicular to initial velocity (ii) uniform magnetic field at an angle with the velocity. and (iii) simultaneous electric and magnetic fields in perpendicular directions with different field strengths.

A proton is incident on a rectangular barrier, calculate the probability of transmission for fixed values of V_0 and E ($V_0 > E$) for the width of barrier ranges from 5 to 10 Fermi, and plot the same.

Generate the interference pattern in Young's double slit-interference and study the variation of intensity with variation of distance of the screen from the slit.

Analyze the Elliptically and circularly polarized light based on two vibrations emerging out of a polarizer represented by two simple harmonic motions at right angles to each other and having a phase difference. Plot the nature of vibrations of the emergent light for different values of phase difference

Generate the pattern of electric field due to a point charge

Sketch the ground state wave function and corresponding probability distribution function for different values of dispalcements of the harmonic oscillator.

Gauss elimination method for solving a system of linear equations.

Solving a second order differential equation using 4^{th} order Runge- Kutta method.

Finding the roots of a nonlinear equation by bisection method.

Reference Books:

Computational physics, An Introduction, R.C. Verma, P.K. Ahluwalia & K.C. Sharma, New Age India, Pvt. Ltd.

An Introduction to computational Physics, Tao Pang, Cambridge University Press.

Simulations for Solid State Physics: An Interactive Resource for Students and Teachers, R.H. Silsbee & J. Drager, Cambridge University Press.

Numerical Recipes: the Art of Scientific Computing, W.H. Press, B.P. Flannery, S.A. Teukolsky & W.T.Vettering, Cambridge University Press.