*Syllabus and Course Scheme*
*Academic year 2014-15*

# M.PHIL. (PHYSICS) -2015


**DEPARTMENT OF PURE AND APPLIED PHYSICS**
**UNIVERSITY OF KOTA**
MBS Marg, Swami Vivekanand Nagar,
Kota - 324 005, Rajasthan, India
**Website: uok.ac.in**

# M.Phil. (Physics) -2015
# Paper-1- Advanced Quantum Mechanics

**Time: 3 hrs.** **Max. Marks: 100**

Note- Four questions, taking one question from every part with 100 percent internal choice are to be set in the question paper. Candidates will be required to answer all the four questions.

## UNIT-1 (Non-relativistic)

**Bosons:** The simple harmonic oscillator, annihilation and creation operators, coupled oscillator, The linear chain, three dimensional lattices and vector fields, classical field theory, second quantization, sources of a field and interaction between fields.
Example: Rayleigh scattering of phonons, Yukawa force, charged bosons.
**Fermions:** Occupation number representation, annihilation and creation operators, anti commutation, second quantization, scattering connection with statistical mechanics, interaction between particles, momentum conservation, Fermions-boson interaction, holes and antiparticles.

## UNIT-II (Non-relativistic)

**Perturbation Theory:** S-matrix, S-matrix expansion, algebraic theory, Diagrammatic representation, momentum representation.
**Density Matrix and Green functions:** Properties of the density matrix, density matrix in statistical mechanics, density matrix for one dimensional free particle, linear harmonic oscillator, symmetries density matrix for particles, one particle Green function, energy-momentum representation, evaluation of two particles Green's function, The hierarchy of Green functions, time independent Green function, matrix representation of the Green function, space representation of time independent Green function, The Born series, The T-matrix.

## UNIT-III (Relativistic)

**Relativistic Quantum Mechanics of Spin ½ Particles:** K.G. equation in momentum space and its drawbacks, solutions of free particle Dirac equation, Lorentz transformation properties of Dirac spinors, Hole theory and charge conjugation, charge conjugate wave function, transformation of Dirac spinors under reflection, charge conjugation and time reversal, Bilinear covariants and their behaviour under C, T, P, CP, CPT and Lorentz transformations, Dirac operators in the Heisenberg representation, constants of motion, velocity in Dirac theory, difficulties of unquantized Dirac theory, quantization of the Dirac field, positron operators and positron spinors, two component neutrino theory, Chirality invariance polarization states of zero rest mass particle and positronium.
**Covariant Perturbation Theory and Applications:** S-matrix expansion in the interaction representation, U-matrix and S-matrix, unitarity, application of S-matrix formalism.

## UNIT-IV (Relativistic)

**Mott Scattering:** Matrix element, spin sum and projection operator, cross section, Helicity change anti spin projection operators, cross-section for polarized electrons.
**e+,e- Annihilation and Compton Scattering:** S-matrix for **e+,e-** annihilation into two photons electron propagator, covariant matrix element for **e+,e-** annihilation onto two photons, matrix element for Compton scattering, prescription for Feynman cross-section for **e+,e-** annihilation into two photons and Compton scattering.
**Positronium-**: Charge parity selection rules for positronium decay, life time calculations for positronium decay into two photons.

**Scope- for section A:**
The scope of part 1 is defined by H.H. Ziman, Element of Advanced Quantum theory (Cambridge University Press 1969) chapter 1 to 3. For part 2 R.P. Feynman Statistical Mechanics (The Benjamin Cummings Pub. Co.Inc.) Chapter 2 and J.M. Ziman, Elements of Advanced Quantum Theory (Cambridge University Press 1969) chapter 4.

**Other references:**
1. D.S. Koltun and J.M. Eisenberg, Quantum Mechanics of Many Degrees of Freedom (John Wiley and Sons, 1988).
2. J.W. Negele and H. Orland, Quantum Many Particles Systems (Addison-Wesley Pub. Co. 1985).
3. A.Z. Capri, Non-relativistic Quantum Mechanics (The Benjamin/Cummings Co.1985).
4. F. Mandl, Introduction to Quantum Field Theory (Inter science publishers Inc.1959).
5. A.L. Fetter and J.D.Walecka, Quantum Theory of Many Particle Systems (Mc-Graw Hill New York 1971)

**For Section-B:** It is based on the chapter 3 and 4 of the book Advanced Quantum Mechanics by J.J. Sakurai (Addison Wesley publishing Co.1982).

**Other references:**
1. J.D Bjorken and S.Drell, Relativistic Quantum Mechanics, vol 1 (Mc-Graw Hill Book Co.1964).
2. C. Itzykshon and J.B. Zuber, Quantum Field Theory (1980) (Mc-Graw Hill Book Co.1930).
3. S.S. Schweber, An Introduction to Relativistic Quantum Field Theory (Harper and Rows New York, 1964).
4. A. Akiezer and V.B. Berestestii, Quantum Electrodynamics (Interscience, New York. 1965).

# Paper-II-Non Linear Dynamics and Computational Techniques

**Time: 3 hrs.** **Max. Marks: 100**

Note- Four question, taking one question from every part with 100 percent internal choice are to be set in the question paper. Candidates will be required to answer all the four questions.

## UNIT-I

**Introduction to Dynamical Systems:** Nonlinear differential equations, physics of nonlinear systems: simple harmonic oscillation, Duffing oscillation, phase space, dynamical equations and constants of motion, logistic map fixed point's stability analysis, bifurcations and their classification, Poincare section and iterative maps.

**Dissipative Systems:** One-dimensional invertible and noninvertible maps, simple and strange attractors, period doubling and universality, invariant measure, Lyapunov exponents, higher dimensional system, Henon maps, Lorentz equation, Fractal geometry, generalized dimensions, examples of Fractals.

## UNIT-II

**Hamiltonian Systems:** Integrability, Liouville's theorem, action-angle variables, introduction to perturbation techniques, KAM theorem, area preserving maps, concepts of chaos.

**Coherence:** Spatial and temporal fundamental, couple signal representation of quasiomonochromatic light, theory of partial coherence power spectrum and intensity distribution, laser-principle and working, elements of holography (on and off axis holography).

## UNIT-III

**Basic Numerical Methods:** Interpolations and approximations, differentiation and integration, zeros and extremes of a single variable function, classical scattering and random number generators.

**Ordinary Differential Equations:** Initial-value problems, Runge-Kutta method, chaotic dynamics of a driven pendulum, boundary-value and eigen value problems, linear equations and Sturm-Liouville problem, The one-dimensional Schrodinger equations.

**UNIT-IV**

**Numerical Methods for Matrices:** Matrices in physics, matrix operations, linear equation systems, zeros and extremes of a multivariable function, eigen value problem, electronic structure of atoms, The Lanczos algorithm and the many-body problem, random matrix.

**Spectral Analysis and Gaussian Quadrature:** The Fourier transforms and orthogonal functions, The Discrete Fourier transform, The Fast Fourier transform, The power spectrum of a driven pendulum, wavelet analysis, Gaussian quadrature.

**Reference:** Tao Pang. An Introduction to Computational Physics, Cambridge University Press. New York, 1997.

# Paper-III (a)-Condensed Matter physics

**Time: 3 hrs.** **Max. Marks: 100**

Note- Four question, taking one question from every part with 100 percent internal choice are to be set in the question paper. Candidates will be required to answer all the four questions.

**UNIT-I**

**Electronic Structure (Theoretical):** Introduction: One-electron approximation, energy-band problem, energy-band methods, brief history of linear methods.

**Canonical Band Theory:** Muffin-tin orbitals and tail cancellation, structure constants and canonical bands, potential function and Wigner-Seitz rule, potential parameters, unhybridised and hybridised bands, state densities and energy scaling.

**One Electron States in a Single Sphere:** Radial basic functions, partial waves & their energy derivatives, logarithmic derivatives & Laurent expansion, potential function and band-width, matrix elements & variational estimate of energies.

**The Liner Method:** Partial waves for a single Muffin-tin, MT Orbital, expansion theorem for MTO tails, energy- independent MTO, the LMTO Secular matrix, LMTO method.

**Atomic-Sphere Approximation (ASA):** The kinetic energy, atomic sphere and the ASA, Muffin-tin orbitals in the ASA, wave function and its character, projected state density and density of electrons, (Qualitative discussion only).

**UNIT-II**

**Electronic Structure (Experimental Determination):** (Basie principles, experimental technique and results are to be discussed).

**Momentum Density and Fermi Surface:** de-Haas-van Alphen effect, positron annihilation spectroscopy and Compton scattering.

**Band Structure and Density of States:** Photoemissions from solids (integral and angle resolved methods), band spectroscopy, inverse photoemission.

**Application of Synchrotron Radiation**: Salient features, flux and spectral distribution, discussion of various components of a synchrotron radiation facility for condensed matter research.

**UNIT-III**

**Magnetism:** Introduction, survey of magnetic proprieties of rare-earth salts and metals, transition metals and their alloys.

**Localized Electron Magnetism**: Weiss molecular field, Brilluoin function for paramagnets, expansion to ferromagnetic ordering, departure form Weiss theory, anti ferromagnetism and ferrimagnetisms (qualitative discussion in two-sub lattice model), Ferrites (only results).

**Itinerant Electron Magnetism**: Paramagnetism of free electrons, ferromagnetism of band electrons, collective electron model due to stronger rigid band model (qualitative discussion only), Slater-Pauling curve.

**Magnetism in High Temperature:** Application of Landau's region (close to transition point), theory of second order phase transition, Bethe-Peierls-Wseiss (BPW) approximation.

**Domain Magnetism:** Basic principles (magneto crystalline anisotropy, magneto static energy, domain walls, magneto strication, magnetization curve and comain wall equilibrium, single domain particles), soft and hard magnetic materials, thin magnetic films and bubble domains.

### UNIT-IV

**Disordered Materials:** Distinction between crystalline and disordered materials, static and dynamic structure factors for liquid metals, pair-correlation function and their relationship with elastic and inelastic x-ray scattering from liquids (only discussion of results), single particle and collective modes, phonon dispersion, extension to liquid alloys, concentration fluctuation in binary alloys.

**Glasses**: Class transition, structural models, thermodynamics of class transition, dynamic theory glass transition, optical, thermal, mechanical, electrical and magnetic properties of glass (simple examples) and their interpretation, phonon dispersion in two-component metallic glasses using atomic theories and pseudopotential approach.

## References:

### UNIT-I

**1.** It is based on Chapter 1 to 7 from the LMTO method by H.L. Skriver, Springer-Verlag, Solid state Science 41. 2.
Electronic Band Structure and its Applications (Ed.) M. Yussouff, Lecturer notes in Physics Vol.283. (Springer-Verlag).

### UNIT-II

1. Compton Scattering (Ed). B. Williams, Mc Graw Hill Co. (1977).
2. Photoemission in Solids (Springer-Verlag) by Leyadn Cardors.
3. Synchrotron Radiation Research (Ed.) H. Winick and S. Doniach (Plenum, New York, 1980)
4. Inverse Photoemission by N.V. Smith (1986).
5. M. J. Cooper, P. E. Mijnarends, N. Shiotani, N. Sakai and A. Bansil, X-ray Compton Scattering. Oxford Science Publications, Oxford University Press, New York (2004).

### UNIT-III

1. The Structures and Properties of Solids 6 (The Magnetic Properties of Solids), J. Crangle, Edward Amold (Publishers) Ltd, London (1977).
2. Physics of Magnetism, Soshin Chikaxumi and Robert E. Kreigor, Publishing Co. Florida (John Wiley and Sons.Inc) (Reprint, 1978)
3. Introduction to the Theory of Magnetism, D. Wagner, Perganon Press, Oxford (1972)
4. Mossbauer Effect and its Applications, V.G. Bhide, Tata McGraw Hill Publishing Co. Ltd, New Delhi (1975).

### UNIT- IV

1. Physics and Chemistry of Liquids, Beer, Noncel Dekkev. (1972).
2. Introduction to Liquid State Physics, P.A. Egelslaff, Academic Press. 1967.
3. An introduction to the Theory of Liquid Metals, T.E. Faber, Cambridge Press.
4. Metallic Classes, Contemporary Physics, Vol.21. No. 143-75 (1980).
5. A Unified Theory of Melting Crystallization and Class Formation, Coll. C2.No.4Vol. 36 (1975).
6. Liquid Meats, N.H. March.
7. Classy Metals, H. Eeck and H.J. Cuntherodt, Springer-Verlag NY

# Paper III (b) – High Energy Physics

**Time: 3 hrs.** **Max. Marks: 100**

Note- Four question, taking one question from every part with 100 percent internal choice are to be set in the question paper. Candidates will be required to answer all the four questions.

## UNIT-I

**Qualitative Introduction:** Particles, resonances, classification into baryons, mesons, leptons and gauge bosons, mark flavours strangeness, charm, bottom and top, additive conservation caves, charge, baryon number, lepton number strangeness and charm members, particle decays, quark structure of hadrons, experimental study of high energy nucleus-nucleus interaction.

**Experimental Parameters:** Cross-section, multiplicity distributions, angular and rapidity distributions, two particle and many particle correlations, comparison of Larder-Larder, Larder- nucleus and nucleus-nucleus collisions.

**Models:** Fire ball model, additive quark model, Lund model, brief description of these models for nucleus-nucleus interactions,

Review of important results in high energy heavy ion interactions about projectile, target fragmentation and multiparti-pariclre production observation of neutron rich isotopes, anolamon effect, rch for collective phenomena in the commission of relativistic a particles, analysis of multiplicity distributions in terms of negative Boltzman distribution, analysis, of rapidity distributions, signal for quark gluon plasma in ultra relativistic, high energy heavy ion interactions.

## UNIT-II

**Modern Detectors:**

**Position Detectors:** Multisite proportional chamber, drift chamber, time projection chamber silicon strip detectors, particle identification choker detectors, transition radiation detectors, multiple ionsation measurement.

**Energy Measurement:** Electron photon shower counters, Hadron calorimeters, calibration monitoring of calorimeters.

**Nuclear Emulsions:** Measurements of position, momentum energy, charge etc..., qualitative description of HA30 (detecteor assembaly used for H.E. heavy ion interactions).

**Relativistic Kinematics:** Lorentz transformation and four vectors, Lorentz invariants, Mandelstern variables, available energy in lab land CM frames, advantage of intersecting storage rings, principle of stochastic cooling.

## UNIT-III

**Lagrangian Formulation Symmetries and Guage Fields:** Lagrangian formulation of particle mechanics, The real scalerfield, variational principle of Noether's theorem, conservation of energy, momentum and angular momentum, complex scalar fields, U (1) gauge transformation, U(1) local gauge transformation, interaction with electromagnetic field, covariant derivative, Dirac fields and global U(1) gauge transformations.

## UNIT-IV

**Electro Weak Interactions:** Early history of weak interactions- Fermi's, Party non conservation, The V-A law, difficulties of Fermi type theories, the naïve intermediate boson hypothesis, Yang Mill field and SU(1) gauge invariance, SU(2), XU(1) model, spontaneous symmetry breaking, couplings of leptons and quarks to gauge fields, leptons and quarks coupling to the scalar field, Feynman rules for the electroweak [SU(2) I, XU(1)] model (no derivation ), muon and the V-A law, gauge muon-decay amplitude, Michel parameters, connection to experimental facts, the process e u u- single photon exchange contribution, weak electromagnetic interference effects in e e- the decay and widths of $Z^-$ e e-, u u-,and $W^- \rightarrow$ e e-.

The scope of the syllabus is defined by the following.

1. (a) Change and O. Well, Elementary Particle Physics-Chapter 1.

(b) Review articles and research papers.
2. (a) Konrad Kloinknocht, Directors for particle Radition Chapter 3, 5, 6.
(b) D. Griffiths, Introduction to Elementary Particles, Chapter 3, and also Change and O. Well.
3. I.H. Ryder, Quantum field theory Chapter 3,(Cambridge University Press1985)
4. E.D. Commines and P.H.Bucksbaun, Weak Interactions of Leptons and Quarks, Cambridge University Press (1983).

**Additional References:**

1. C. Itzykson and J.B. Zuber, Quantum Field Theory, Mc. Graw Hill Book Co.
2. C.Kane, Modern Elementary Particle Physics Additional-Werely Publishing Co. (1987).
3. C.Quigg, Gauge Theories of the Strong, Weak and Electromagnetic Interactions, (The Benjamin Publishing Co. (1983).
4. P.H. Frampton, Gauge Field Theories, Benjamin Publishing Co (1987).
5. T .D. Lee, Particle Physics and Introduction to Field Theory, Herwood. New York.(1981)

## Paper III (c) - Plasma Physics

**Time: 3 hrs.** **Max. Marks: 100**

Note- Four question, taking one question from every part with 100 percent internal choice are to be set in the question paper, Candidates will be required to answer all the four questions.

### UNIT-I

Maxwell's equations, derivation and interpretation of Maxwell's equations with time varying fields, vector and scalar potentials and gauge transformations, Green function for the wave equation, derivation of equations of macroscopic electromagnetism, Conservation of energy, momentum and angular momentum for a system of charged particles and electromagnetic fields, Poynthing theorem for harmonic fields.

### UNIT-II

**Nonlinear Equations and Singular Perturbation Methods:** Free oscillations of a pendulum, operational analysis of nonlinear dynamical systems, Krylott and Bogoliuboff method, topological methods, nonlinear conservative systems, phase trajectories of the vander Pol equation, singular perturbation Poincare’s method, Method of strained coordinates,Variational method, fundamental concepts in wave problems, The formal derivation of asymptotic equations, Reductive perturbation method, KBM method, The method of multiple scales.

### UNIT-III

**The Vlasoy Theory of Plasma Waves and Instability:** Solution of linearized Vlasov equation for electrostatic perturbations, Longnuir ion-sound waves, Landau damping, electromagnetic waves, The Vlasov theory of small amplitude waves in uniformly magnetized plasma, waves along and perpendicular to uniform magnetic field, waves in any inhomogeneous magnetized hot plasma, nonlinear electrostatic BOK waves, The two stream instability, The Nyquist method and Penrose criterion for stability, ion acoustic instability, instabilities anisotropic plasmas.

### UNIT-IV

Detailed study of any one of the following topies or any other topic active research area:

(i) Nonlinear Vlasov theory of plasma waves and instabilities.
(ii) Strong wave particle interaction.
(iii) Coherent radiation generation.
(iv) Pulse Propagation in plasma
(v) Neoclassical transport theory.
(vi) Plasma Channels.

**Note:** The topic under Unit 4 will be decided by the teacher concerned every year.

**References:**

For Unit-1: J.D. Jackson, Classical Electrodynamics, Chapter 6.

For Unit-2: Pipes and Harvill, Applied Mathematics for Engineers and Physicists, III .
Edition, Chapter 15, Jaffrey and T. Kawahara, Asymptotic method in non liner wave theory, Chapter and 3. For Unit-3 and 4: N.A. Krall and A.W. Trivalpiece, Principles of Plasma Physics, Mc-Graw Hill, Chapters, 8.

**Experiment M. Phil. (Physics):**

X-ray spectrometer experiment
Compton scattering experiment
Four probe experiment (samples: semi conductor, super conductor)
Parametric amplifier experiment
Hall effect experiment.
Band structure experiment study.
Scintillator counters experiment.
GM counters experiment.
Air Track experiment.
Modulus of rigidity experiment.

**Dissertation:** One-electron states in a single sphere, radial basics functions, partial waves and their energy derivatives, logarithmic derivatives and Laurent expansion theorem for MTO tails, energy-independent, MTO, The LMTO secular matrix, LMTO method.

Starting out as the Department of Materials Science the School expanded its scope and became the School of Pure & Applied Physics. The activities of the School encompass teaching, research and extension activities, promoting Physics, the basis of all the concrete sciences, which in its pure theoretical aspects becomes our reading of the way Nature expresses herself through Mathematics the queen of the abstract sciences.Â  (20) â€“ Specializations: Materials Science and Astrophysics â€¢ M.Phil. (10) â€¢ PhD. Areas of Research.Â  The faculty members of the School of Pure and Applied Physics are providing free consultancy services to the teachers. and researchers of the nearby institutions and affiliated colleges. The School has initiated to open a centre for industrial. While studying at the Department you get a high-quality education in the field of physics. Bachelors begin to participate in scientific work during the last undergraduate courses and magister students are full-fledged members of the scientific center. Our graduates are working in the best laboratories and high-tech companies around the world. Class schedule. The Department of Applied Physics prepares students for academic and industrial careers at the forefront of science and technology. Teaching and research are focused on fundamental issues in condensed matter and optical physics and on the practical application of these concepts and techniques to technology. This balance between fundamental science and application makes our program highly interdisciplinary, having strong collaborations with Physics and Chemistry, as well as Electrical, Mechanical, Chemical, and Biomedical Engineering. Explore the exciting opportunities in the Department of Appl...