Course curriculum and scheme of examination for the students who admitted into
M.Sc. (Physics) from 2014-15 Batch onwards

I SEMESTER

				Max. marks:100		
Sl. No.	Paper Title	No. of credits	Hours per week	Internal	External	Exam time(hrs)
1.	Mathematical Physics	4	5	30	70	3hrs
2.	Classical Mechanics	4	5	30	70	3hrs
3.	Quantum Mechanics-I	4	5	30	70	3hrs
4.	Electronics(General)	4	5	30	70	3hrs
5.	Practical-I	4	8	30	70	3hrs
6.	Practical-II	4	8	30	70	3hrs

II SEMESTER

				Max. marks:100		
Sl. No.	Paper Title	No. of credits	Hours per week	Internal	External	Exam time(hrs)
1.	Quantum Mechanics-II	4	5	30	70	3hrs
2.	Statistical Mechanics	4	5	30	70	3hrs
3.	Computational Methods and Programming	4	5	30	70	3hrs
4.	Solid State Physics (General)	4	5	30	70	3hrs
5.	Practical-III	4	8	30	70	3hrs
6.	Practical-IV	4	8	30	70	3hrs
7.	Non-Core: Paper – I History of Physics	4	4	30	70	3hrs

III SEMESTER

				Max. marks:100		
Sl. No.	Paper Title	No. of credits	Hours per week	Internal	External	Exam time(hrs)
1.	Nuclear and Particle Physics	4	5	30	70	3hrs
2.	Advanced Quantum Mechanics	4	5	30	70	3hrs
3.	Condensed Matter Physics-I	4	5	30	70	3hrs
4.	Condensed Matter Physics-II	4	5	30	70	3hrs
5.	Practical-V	4	8	30	70	3hrs
6.	Practical-VI	4	8	30	70	3hrs
7.	Non-Core: Paper- II Modern concepts of Physics	4	4	30	70	3hrs

IV SEMESTER

				Max. marks:100		
Sl. No.	Paper Title	No. of credits	Hours per week	Internal	External	Exam time(hrs)
1.	Electromagnetic Theory and Modern Optics	4	5	30	70	3hrs
2.	Molecular and Solid State Spectroscopy	4	5	30	70	3hrs
3.	Condensed Matter Physics-III	4	5	30	70	3hrs
4.	Condensed Matter Physics-IV	4	5	30	70	3hrs
5.	Project	8	16	--	200	6hrs
Total for Core Papers		96	144	660	1740	
Total for Non-Core Papers		8	8	60	140	
Grand Total:		104	152	720	1880	

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(with effect from the batch admitted in 2009-10 academic year onwards)

M.Sc. Physics (I Semester)

Paper I : MATHEMATICAL PHYSICS PHY 1.1

Unit-I

Special Functions: : Solution by series expansion: Legendre, Associated Legendre, Bessel, Hermite and Lagaurre equations: physical applications: Generating functions: orthogonality properties and recursion relations.

Unit-II

Integral Transforms, Laplace transform; first and second shifting theorems: Inverse LT by partial fractions; LT of derivative and integral of a function; Fourier series; Fourier series of arbitrary period; Half-wave expansions; Partial sums; Fourier n integral and transformations; FT of delta function.

Unit-III

Complex Variables: Complex, Algebra, Cauchy – Riemann Conditions, Analytic functions, Cauchy's integral theorem, Cauchy's integral formula, Taylor's Series, Laurent's expansion, Singularities, Calculus of Residues, Cauchy's Residue theorem, Evaluation of Residues , Evaluation of contour integrals.

Unit-IV

Tensor Analysis: Introduction, Transformation of Co-ordinates, Contravariant, Covariant and Mixed tensors, Addition and multiplication of tensors, contraction and Quotient Law. The line element, fundamental tensors.

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Text and reference books:

1. Mathematical Methods for Physics. By G.Arfken
2. Laplace and Fourier Transforms"-by Goyal and Gupta. Pragati Prakashan Meerut
3. Matrices and Tensors for Physicists by A W.Joshi
4. Mathematical Physics " by B.D.Gupta. Vikas Publishing House, New Delhi
5. Complex Variables " Schaum Series"
6. Vector and Tensor Analysis "Schaum Series"
7.

NOTE : Question paper contains 5 questions. **FOUR** questions with internal choice have to be set from each unit. The 5thquestion has 4 short answers question covering units I to IV and any two be answered.

M.Sc. Physics (I Semester)

Paper II : CLASSICAL MECHANICS PHY 1.2

Unit-I

1. Mechanics of a particle. Mechanics of a system of particles, constraints, D'Alembert's principle and Lagrange's equations, Velocity Dependent potentials and the Dissipation function Simple applications of the Lagrangian Formulation
2. Hamilton's principle, some techniques of the calculus of variations. .Derivation of Lagrange's equations from Hamilton's principle. Conservation theorems and symmetry properties, Energy function and the conservation of Energy

Unit-II

3. Reduction to the equivalent one body problem. The equation of motion and first Integrals, The equivalent One – Dimensional problem and classification of orbits, The differential equation for the orbit, and Integrable power –law potentials, Conditions for closed orbits (Bertrand's theorem), The Kepler problem inverse square law of force , The motion in time in the Kepler problem, Scattering in a central force field..
4. Legendre transformations and Hamilton's equations of motion. Cyclic Coordinates and conservation theorems, Derivation of Hamilton's equation of motion from variational principle, Principle of Least Action.

Unit-III

5. Equations of canonical transformation, Examples of Canonical transformations, The harmonic Oscillator, Poisson brackets and other Canonical invariants, Equations of motion, Infinitesimal canonical transformations, and conservation theorems in the poisson bracket formulation, the angular momentum poisson bracket relations.

6. Hamilton – Jacobi equation of Hamilton's principal function, The Harmonic oscillator problem as an example of the Hamilton – Jacobi Method, Hamilton –Jacobi equation for Hamilton's characteristic function. Action – angle variables in systems of one degree of freedom.

Unit-IV

7. Independent coordinates of rigid body. , The Euler angles, Euler's theorem on the Motion of a rigid body, Infinitesimal rotations, Rate of change of a vector, The Coriolis Effect.
8. The Inertia tensor and the moment of inertia, The Eigenvalues of the inertia tensor and the principal axis transformation, Solving rigid body problems and Euler equations of motion, Torque – free motion of a rigid body
9. The Eigenvalue equation and the principal axis transformation, Frequencies of free vibration, and normal coordinates, Free vibrations of a linear triatomic molecule

TEXT BOOKS :" Classical Mechanics " by H.Goldstein (Addison-Wleley, 1st & 2nd ed)

REFERENCE :"Classical Dynamics of Particles and Systems" by J.B.Marion.

NOTE : Question paper contains 5 questions. **FOUR** questions with internal choice have to be set from each unit. The 5th question has 4 short answers question covering units I to IV and any two be answered.

M.Sc. Physics (I Semester)

Paper III : QUANTUM MECHANICS I PHY 1.3

Unit-I

Why QM? Revision; Inadequacy of classical mechanics; Schrodinger equation; continuity equation; Ehrenfest theorem; admissible wave functions; Stationary states. One-dimensional problems, wells and barriers. Harmonic oscillator by Schrodinger equation.

Linear Vector Spaces in Quantum Mechanics: Vectors and operators, change of basis, Dirac's bra and ket notations. Eigen value problem for operators. The continuous spectrum. Application to wave mechanics in one dimension. Hermitian, unitary, projection operators. Positive operators. Change of orthonormal basis. Orthogonalization procedure.

Unit-II

Angular momentum: commutation relations for angular momentum operator. , Angular Momentum in spherical polar coordinates, Eigen value problem for L^2 and L_z, L_+ and L_- operators Eigen values and eigen functions of Rigid rotator and Hydrogen atom

Unit III

Time-independent perturbation theory; Non-degenerate and degenerate cases; applications to a)normal helium atom b) Stark effect in Hydrogen atom. Variation method. Application to ground state of Helium atom. WKB method.

Unit IV

Time dependent perturbation : General perturbations, variation of constants, transition into closely spaced levels –Fermi's Golden rule. Einstein transition probabilities, Interaction of an atom with the electro magnetic radiation. Sudden and adiabatic approximation.

TEXT AND REFERENCE BOOKS

Merzbecher, Quantum Mechanics
L I Schiff, Quantum Mechanics (Mc Graw-Hill)
B Craseman and J D Powell, Quantum Mechanics (Addison Wesley)
A P Messiah, Quantum Mechanics
J J Sakural, Modem Quantum Mechanics
Mathews and Venkatesan Quantum Mechanics
Quantum Mechanics" by R.D. Ratna Raju

NOTE : Question paper contains 5 questions. **FOUR** questions with internal choice have to be set from each unit. The 5thquestion has 4 short answers question covering units I to IV and any two be answered.

M.Sc. Physics (I Semester)

Paper IV : ELECTRONICS (General) PHY 1.4

UNIT I

Operational Amplifiers

Differential Amplifier –circuit configurations - dual input, balanced output differential amplifier – DC analysis – Ac analysis, inverting and non inverting inputs CMRR - constant current bias level translator .

Block diagram of a typical Op-Amp-analysis. Open loop configuration inverting and non-inverting amplifiers. Op-amp with negative feedback- voltage series feedback – effect of feedback on closed loop gain input resistance output resistance bandwidth and output offset voltage- voltage follower.

UNIT-II

Practical Op-amps

Input offset voltage- input bias current-input offset current, total output offset voltage, CMRR frequency response.

DC and AC amplifier- summing, scaling and averaging amplifiers, instrumentation amplifier, integrator and differentiator.

Oscillators principles – oscillator types – frequency stability – response – The phase shift oscillator, Wein bridge oscillator – LC tunable oscillators – Multivibrators- Monostable and astable –comparators – square wave and triangular wave generators.

Voltage regulators – fixed regulators – adjustable voltage regulators switching regulators.

UNIT III

Communication Electronics

Amplitude modulation – Generation jof AM waves – Demodulation of AM waves – DSBSC modulation. Generation of DSBSC wages., coherent detection of DSBSC waves, SSB modulation, Generation and detection of SSB waves. Vestigial side band modulation, Frequency division multiplexing (FDM).

Digital Electronics

Combinational Logic- Decoder- encoders- Multiplexer(data selectors)-application of multiplexer - De multiplexer(data distributors) –

Sequential Logic- Flip-Flops: A 1 bit memory – the R-S Flip – Flop, JK Flip-Flop – JK master slave Flip-Flops – T- Flip – Flop – D Flip – Flop – Shift registers – synchronous and asynchronous counters – cascade counters.

UNIT IV

Microprocessors

Introduction to microcomputers – memory – input/output –interfacing devices

8085 CPU -Architecture – BUS timings – Demultiplexing the address bus – generating control signals – instruction set – addressing modes – illustrative programmes – writing assembly language programmes –looping, counting and indexing – counters and timing delays – stack and subroutine.

Introduction to micro controllers-8051 micro controllers-architecture & pin description-Parallel I/O ports – memory organization.

Text and Reference Books

Electronic devices and circuit theory by Robert Boylested and Louis Nashlsky PHI 1991

Op-Amps & Linear integrated circuits by Ramakanth A.Gayakwad PHI 1991

Semi Conductor Electronics by A.K.Sharma New Age International Publishers.

Fundamentals of Digital Circuits by A.Ananda Kumar,PHI,New Delhi.

Digital principles and applications by A.P.Malvino and Donald P.Leech TMH 1993

Microprocessor Architecture, Programming and Applications with 8085/8086 by Ramesh S.Gaonkar, Wiely-Eastern 1987.

Micro Controllers: Theory and Applications by Ajay V. Deshmukh,Tata Mc Graw- Hill.New Delhi, 2005

Electronics-anlog and digital – Nagarath PHI

NOTE : Question paper contains 5 questions. **FOUR** questions with internal choice have to be set from each unit. The 5thquestion has 4 short answers question covering units I to IV and **any two** be answered.

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M.Sc. Physics (II Semester) **PHY 2.1 (09)**

Paper-I QUANTUM MECHANICS-II

UNIT-I

Spin and Total angular momentum;

Spin angular momentum and Paulis spin matrices

Total angular momentum J. Explicit matrices for J^2, J_x, J_y & J_z.Combination of two angular moment and tensor operator: Clebsch-Gordon coefficients for j_1=1/2 , j_2 =1/2 and j_1=1 , j_2 =1/2 Wigner-Eckart theorem.

UNIT-II

Quantum Dynamics and identical particles

Equation of motion in Schrödinger's picture and Heisenberg's picture, correspondence between the two. Correspondence with classical mechanics. Application of Heisenberg's picture to Harmonic oscillator. The indistinguishability of identical particles – The state vector space for a system of identical particles – Creation and annihilation operators- continuous one particle system- Dynamical variables – the Quantum dynamics of identical particle systems

UNIT-III

Scattering Theory

Introduction of scattering – notion of cross section – scattering of a wave packet- scattering in continuous stream model – Green's function in scattering theory – Born's approximation – first order approximation – criteria for the validity of Born's approximation . Form factor- scattering from a square well potential – partial wave analysis – Expansion of a plane wave – optimal theorem – calculation of phase shifts – low energy limit – energy dependence of β_e - scattering from a square well potential.

UNIT-IV

Molecular Quantum Mechanics

The Born-Openheimer Approximation – The hydrogen molecule ion the Hydrogen molecule – The valance bond method – The molecular orbital method- Comparison of the methods – Heitler-London method.(Ref : Atkins, Chapter-9, 279-294).

Text books

Merzbecher, Quantum Mechanics
L I Schiff, Quantum Mechanics (Mc Graw-Hill)
B Craseman and J D Powell, Quantum Mechanics (Addison Wesley)
A P Messiah, Quantum Mechanics
J J Sakural, Modem Quantum Mechanics
Mathews and Venkatesan Quantum Mechanics
Quantum Mechanics" by R.D. Ratna Raju
Quantum mechanics by Kakani and Chandalia

NOTE : Question paper contains 5 questions. **FOUR** questions with internal choice have to be set from each unit. The 5^{th}question has 4 short answers question covering units I to IV and any two be answered.

M.Sc. Physics (II Semester)
Paper II : Statistical Mechanics PHY 2.2 (09)

Classical Statistical Mechanics

UNIT I

Foundations of statistical mechanics; specification of states of a system, contact between statistics and thermodynamics, Postulate of classical stastical mechanics- phase space, trajectories - Ensembles-micro canonical,canonical and grand canonical - Density of states - Liouville's theorem -equi-partition theorem- Classical ideal gas: entropy of ideal gas in micro canonical ensemble- Gibb's paradox.

UNIT-II

2.Canonical ensemble - ensemble density- partition function - Energy fluctuations in canonical ensemble -Grand canonical ensemble- Density fluctuations in the Grand canonical ensemble- Equivalence between the canonical ensemble and Grand canonical ensemble.

Quantum statistical mechanics

UNIT III

3. Postulates of quantum statistical mechanics-Density matrix- Ensembles in quantum statistics- statistics of indistinguishable particles, Maxwell-Boltzmann, Bose-Einstein and Fermi- Dirac statistics - Thermodynamic properties of ideal gases on the basis of micro canonical and grand canonical ensemble. The Partition function: Derivation of canonical ensemble using Darwin and Fowler method.

UNIT IV

4.Ideal Fermi gas : Equation of state of an ideal Fermi gas, theory of White dwarf stars, Landau diamagnetism.
Ideal Bose gas : Photons – Phonons - Bose Einstein condensation- Random walk- Brownian motion

Text and Reference Books:

Statistical and Thermal Physics by S. Lokanadham and R.S.Gambhir (PHI).
Statistical Mechanics by K. Huang (Wiley Eastern)
Statistical Mechanics: Theory and applications by S.K. Sinha
Fundamentals of Statistical and Thermal Physics by F. Reif
Statistical Mechanics by Gupta and Kumar, Pragathi Prakashan Pub. Meerut.

NOTE : Question paper contains 5 questions. **FOUR** questions with internal choice have to be set from each unit. The 5thquestion has 4 short answers question covering units I to IV and any two be answered.

M.Sc. Physics (II Semester) PHY 2.3 (09)

Paper-III COMPUTATIONAL METHODS AND PROGRAMMING

UNIT-I Fundamentals of C Language:

C character set-Identifiers and Keywords-Constants-Variables-Data types-Declarations of variables – Declaration of storage class-Defining symbolic constants –Assignment statement.

Operators - Increment and decrement operators –Conditional operators.

Arithmetic expressions – Precedence of arithmetic operators – Type converters in expressions – Mathematical (Library) functions – data input and output – The get char and put char functions-Scanf - Printf-simple programs.

a) Control statements and Arrays: If-Else statements –Switch statement-The operator –GO TO – While, Do-While, FOR statements-BREAK and CONTINUE statements.

b)Arrays: One dimensional and two dimensional arrays –Initialization –Type declaration-Inputting and outputting of data for arrays –Programs of matrices addition, subtraction and multiplication

c)User Define functions: The form of C functions –Return values and their types –calling a function – Category of functions. Nesting of functions. Recursion. ANSI C functions-Function declaration. Scope and life time of variables in functions.

UNIT II-MATLAB and Applications

C character Basics of Mat lab- Mat lab windows – On-line help- Input-Output-File types-Platform Dependence-Creating and working with Arrays of Numbers – Creating, saving, plots printing Matrices and Vectors – Input – Indexing – matrix Manipulation-Creating Vectors Matrix and Array Operations Arithmetic operations-Relational operations – Logical Operations – Elementary math functions, Matrix functions – Character Strings Applications- Linear Algebra,-solving a linear system, Gaussian elimination, Finding Eigen values and eigenvectors, Matrix factorizations Curve Fitting and Interpolation – Polynomial curve fitting on the fly, Least squares curve fitting, General nonlinear fits, Interpolations

UNIT-III Linear and Non –linear equations:

Solution of Algebra and transcendental equations-Bisection, Falsi position and Newton-Rhapson methods-Basic principles-Formulae-algorithms

(b) Simultaneous equations:

Solutions of simultaneous linear equations-Guass elimination and Gauss Seidel iterative methods-Basic principles- Formulae-Algorithms

UNIT-IV

(a) Interpolations:

Concept of linear interpolation-Finite differences-Newton’s and Lagrange’s interpolation formulae-principles and Algorithms

(b) Numerical differentiation and integration:

Numerical differentiation-algorithm for evaluation of first order derivatives using formulae based on Taylor’s series-Numerical integration-Trapezoidal and Simpson’s 1/3 rule-Formulae-Algorithms

Reference books:

1.Numerical Methods, E. Balaguruswamy, Tata McGraw Hill
2.Computer oriented numerical methods-Rajaraman
3. Y.Kirani Singh and B.B.Chaudhuri, MATLAB Programming, Prentice-Hall India,2007
4. Rudra Pratap, Getting Started with Matlab 7, Oxford, Indian University Edition,2006
5. Stormy Attaway: A Practical introduction to programming and problem solving, Elsevier 2012.

NOTE : Question paper contains 5 questions. **FOUR** questions with internal choice have to be set from each unit. The 5thquestion has 4 short answers question covering units I to IV and any two be answered.

M.Sc. Physics (II Semester) PHY 2.4 (09)
Paper-IV SOLID STATE PHYSICS (General)

UNIT I

CRYSTAL STRUCTURE:

Periodic array of atoms—Lattice translation vectors and lattices, symmetry operations, The Basis and the Crystal Structure, Primitive Lattice cell, Fundamental types of lattices—Two Dimensional lattice types, three Dimensional lattice types, Index system for crystal planes, simple crystal structures-- sodium chloride, cesium chloride and diamond structures.

UNIT II

CRYSTAL DIFFRACTION AND RECIPROCAL LATTICE:

Bragg's law, Experimental diffraction methods-- Laue method and powder method, Derivation of scattered wave amplitude, indexing pattern of cubic crystals and non-cubic crystals (analytical methods). Geometrical StructureFactor, Determination of number of atoms in a cell and position of atoms. Reciprocal lattice, Brillouin Zone, Reciprocal lattice to bcc and fcc Lattices.

UNIT III

FREE ELECTRON FERMI GAS:

Energy levels and density of orbitals in one dimension, Free electron gas in 3 dimensions, Heat capacity of the electron gas, Experimental heat capacity of metals, Motion in Magnetic Fields-Hall effect, Ratio of thermal to electrical conductivity.

FERMI SURFACES OF METALS:

Reduced zone scheme, Periodic Zone schemes, Construction of Fermi surfaces, Electron orbits, hole orbits and open orbits, Experimental methods in Fermi surface studies-- Quantization of orbits in a magnetic field, De-Hass-van Alphen Effect, extremal orbits, Fermi surface of Copper.

UNIT IV

THE BAND THEORY OF SOLIDS:

Nearly free electron model, Origin of the energy gap, The Block Theorem, Kronig-Penny Model, wave equation of electron in a periodic potential, Crystal momentum of an electron-Approximate solution near a zone boundary, Number of orbitals in a band--metals and isolators. The distinction between metals, insulators and semiconductors

TEXT BOOKS:

1.Introdcution to Solid State Physics, C.Kittel, 5th edition,

2.Solid State Physics, A.J.DEKKER.

NOTE : Question paper contains 5 questions. **FOUR** questions with internal choice have to be set from each unit. The 5thquestion has 4 short answers question covering units I to IV and any two be answered.

M.Sc. PHYSICS (III rd semester)

Paper-I NUCLEAR AND PARTICLE PHYSICS PHY 3.1

UNIT-I

1. INTRODUCTION :

Objective of studying Nuclear Physics, Nomenclature, nuclear radius, mass & Binding energy, angular momentum, magnetic dipole moment, Electric quadrupole moment, parity and symmetry, domains of instability, Energy levels, mirror nuclei.

2. NUCLEAR FORCES :

Characteristics of Nuclear Forces- Ground state of deuteron, scattering cross-sections, qualitative discussion of neutron-proton and proton- proton scattering at low energies- charge independence, spin dependence and charge symmetry of nuclear forces - exchange forces and tensor forces- Meson theory of nuclear forces(Yukawa's Potential).

UNIT-II

3.NUCLEAR MODELS:

Weisazacker's semi-empirical mass formula- mass parabolas- Liquid drop model -Bohr –Wheeler theory of nuclear fission - Nuclear shell model : magic numbers, spin orbit interaction, prediction of angular momenta and parities for ground states, Collective model., More-realistic models

4 NUCLEAR DECAY:

Alpha decay process, Energy release in Beta-decay, Fermi's theory of β - decay, selection rules, parity violation in β -decay, Detection and properties of neutrino, energetics of gamma decay, selection rules, angular correlation, Mossbauer effect.

UNIT-III

5. **NUCLEAR REACTIONS** :

Types of reactions and conservation laws, Nuclear kinematics - the Q – equation, threshold energy- Nuclear cross section

6. **NUCLEAR ENERGY**

Nuclear fission- energy release in fission- Stability limit against spontaneous fission, Characteristics of fission, delayed neutrons, Nuclear fusion, prospects of continued fusion energy. Four factor formula for controlled fission (nuclear chain reaction)-nuclear reactor- types of reactors.

UNIT-IV

7. ELEMENTARY PARTICLE PHYSICS:

Classification - Particle interactions and families, symmetries and conservation laws (energy and momentum, angular momentum, parity, Baryon number, Lepton number, isospin, strangeness quantum number)

Discovery of K-mesons and hyperons (Gellmann and Nishijima formula) and charm, Elementary ideas of CP and CPT invariance, SU(2), SU(3) multiplets, Quark model.

8.ACCELERATORS:

Electrostatic accelerators, cyclotron accelerators, synchrotrons, linear accelerators, colliding beam accelerators.

9. APPLICATIONS OF NUCLEAR PHYSICS:

Trace Element Analysis, Rutherford Back-scattering, Mass spectrometry with accelerators, Diagnostic Nuclear Medicine, Therapeutic Nuclear Medicine.

TEXT BOOKS :

Nuclear Physics by D.C.Tayal, Himalaya publishing Co.,

Introductory Nuclear Physics Kenneth S. Krane

Reference Books:

1. Introduction to Nuclear Physics by Harald A.Enge
2. Concepts of Nuclear Physics by Bernard L.Cohen.
3. Introduction to High Energy physics by D.H. Perkins
4. Introduction to Elementary Particles by D. Griffiths
5. Nuclear Physics by S.B.Patel, Wiley Eastern Ltd.,
6. Fundamentals of Nuclear Physics by B.B. Srivastava , Rastogi Pub,. Meerut.

NOTE : Question paper contains 5 questions. FOUR questions with internal choice have to be set from each unit. The 5th question has 4 short answers question covering units I to IV and any two be answered.

M.Sc., Physics(III Semester)
Paper-II Advanced Quantum Mechanics PHY 3.2

Relativistic quantum mechanics:

Unit - I

Klien –Gordan equation –continuity equation (probability and Current density) - Klien –Gordan equation in presence of electromagnetic field – Dirac equation (for a free particle) - probability and Current density – constants of motion - Dirac equation in presence of electromagnetic fields

Unit - II

Hydrogen atom – Covariant notation – Covariance of Dirac equation - Invariance of Dirac equation under Lorenz transformation – Pure rotation and Lorenz transformation. Charge conjugation – Hole theory and Charge conjugation – projection Operators for energy and spin - bilinear covariant – Dirac equation for Zero mass and spin ½ particles.

Filed Quantization:

Unit - III

Introduction for quantization of fields – Concept of field Hamiltonian formulation of classical field – real scalar field Schrodinger field – Dirac field – Maxwell's field – Quantum equation of the field – quantization of real scalar field and second quantization – Quantization of complex scalar field – Quantization of schrodinger field - quantization of Dirac field.

Unit - III

The Hamiltonian in the radiation field – The interaction term in the semi classical theory of radiation – quantization of radiation field .

Covariant perturbation theory, S-matrix expansion in the interaction picture, Feynman diagrams and Feynman rules for Q.E.D. Thompson scattering, Compton scattering and Miller scattering. A brief introduction to charge and mass renormalization, Bethe's treatment of Lamb shift.

Books

1.	Advanced Quantum Mechanics	J. Sakurai
2.	Relativistic Quantum Fields. Vols. I & II	Bjorken and Drell
3.	Quantum Field Theory	Mandl
4.	Particles and Fields	Lurie
5.	Quantum Theory of Fields. Vols. I & II	Weinberg

NOTE : Question paper contains 5 questions. **FOUR** questions with internal choice have to be set from each unit. The 5thquestion has 4 short answers question covering units I to IV and any two be answered.

M.Sc. Physics (III Semester)

Paper III: Condensed Matter Physics -1 **PHY3.3**

UNIT I

1 Defects: Properties of metallic lattices and simple alloys: The structure of metals – classification of lattice defects. Configurational -entropy –The number of vacancies and interstitial as function of temperature –The formation of lattice defects in metals. Lattice defect in ionic crystals and estimation of concentration of defects in ionic crystals. Edge and screw dislocation The Frank read mechanism of dislocation multiplication.

UNIT-II

Optical Properties:

Optical and thermal electronic excitation in ionic crystals, The ultraviolet spectrum of the alkali halides; excitons, Illustration of electron-hole interaction in single ions, Qualitative discussion of the influence of lattice defects on the electronic levels, Non stoichiometric crystals containing excess metal, The transformation of F centers into F_1 centers and viceversa, Photoconductivity in crystals containing excess metal, The photoelectric effect in alkali halides, Coagulation of F centers and colloids, Color centers resulting from excess halogen, Color centers produced by irradiation with X-rays.

Luminescence General remarks, Excitation and emission , Decay mechanisms, Thallium-activated alkali halids, The sulfide phosphors, Electroluminescence.

UNIT-III

Lattice Vibrations and Thermal Properties

Elastic waves in one dimensional array of identical atoms. Vibrational modes of a diatomic linear lattice and dispersion relations. Acoustic and optical modes. Infrared absorption in ionic crystals. Phonons and verification of dispersion relation in crystal lattices.

Lattice heat capacity – Einstein and Debye theories. Lattice thermal conductivity- Phonon mean free path . Origin of thermal expansion and Gruneisen relation.

UNIT IV: Magnetic Properties of Solids

Quantum theory of Para magnetism, Crystal Field Splitting, Quenching of the orbital Angular Momentum Ferromagnetism Curie point and the Exchange integral, Saturation Magnetization at Absolute Zero, Magnons, Bloch's $T^{3/2}$ law. Ferromagnetic Domains. Antiferromagnetism The two-sublattice model, Superexchage interaction Ferrimagnetism The structure of ferrites, The saturation magnetization, Elements of Neel's theory.

(Solid State Physics by C.Kittel Chapters 14 and 15)

<u>Text and Reference Books</u>

1. Madelng : Introduction to Solid State theory
2. Callaway: Quantum theory of solid state
3. A.J.Dekker: Solid state physics
4. C.Kittel :Solid State Physics
5. Solid State Physics S.O.Pillai New Age International

NOTE : Question paper contains 5 questions. **FOUR** questions with internal choice have to be set from each unit. The 5th question has 4 short answers question covering units I to IV and any two be answered.

M.Sc. Physics (III Semester)

Paper IV: Condensed Matter Physics -II PHY3.4

UNIT- I Elements of group theory

Introduction to crystallographic point groups, the five platonic solids, procedure for symmetry classification of molecules, class , matrix notation for geometrical transformations, matrix representation of point groups , reducible and irreducible representations, great orthoganality theorem and its consequences, Character tables for C_{2V} and C_{3V} point groups, Mullikan symbolism, Symmetry species.

Unit II: Elements of Ligand field theory Electronic spectra

Concept of ligand field and crystal field. Free ion configurations- terms and states. Derivation of free ion terms for d^1 and d^2 configuration. Energy ordering of terms- Hund's rules. Strength of crystal fields, Crystal field potentials for O_h and T_d fields. Meaning of Dq. Construction of ligand field energy level diagrams- effect of weak crystal fields on terms. Splitting due to lower symmetries Electronic spectra of d^1 and d^9 systems.T-S Diagrams

Electrical Properties of Solids

Unit-III Dielectrics

Macroscopic description of the static dielectric constant , The static electronic and ionic polarizabilities of molecules , Orientational Polarization, The static dielectric constant of gases. The internal field according to Lorentz, The static dielectric constant of solids, Clasius -Mosetti equation The complex dielectric constant and dielectric losses, Dielectric losses and relaxation time, Cole-Cole diagrams.The classical theory of electronic polarization and optical absorbtion.

Unit IV Ferroelectrics

General properties of ferroelectric materials. Classification and properties of representative ferroelectrics, the dipole theory of ferroelectricity, objections against the dipole theory, Ionic displacements and the behaviour of $BaTiO_3$ above the curie temperature, the theory of spontaneous polarization of $BaTiO_3$. Thermodynamics of ferroelectric transitions, Ferroelectric domains.

Text Books:

1. Chemical applications of group theory – F.A. Cotton
2. Spectroscopy of molecules - Veera Reddy
3. Solid State Physics by A.J.Dekker (Macmillan)
4. Solid State Physics by C.Kittel

NOTE : Question paper contains 5 questions. **FOUR** questions with internal choice have to be set from each unit. The 5thquestion has 4 short answers question covering units I to IV and any two be answered.

M.Sc, (IV Semester)

Paper-I : ELECTROMAGNTIC THEORY AND MODERN OPTICS PHY4.1

UNIT-I Electromagnetic Theory

Maxwell's equations –General wave equation-Propagation of light in isotropic dielectric medium –dispersion –Propagation of light in conducting medium –Skin depth –Reflection and refraction at the boundary of a dielectric interface-Fresenel's equations-Propagation of light in crystals – double refraction.

Electromagnetic Radiation –Retarded Potentials –Radiation from an Oscillating dipole –Linear Antenna –Lienard-Wiechert Potentials.

UNIT-II Lasers

Lasers: Introduction – directionality- brightness- monochromacity- coherence – relation between the coherence of the field and the size of the source – absorption and emission processes - the Einstein coefficients - amplification in a medium- laser pumping Boltzman's principle and the population of energy levels – attainment of population inversion - two level – three level and four level pumping .

Optical feedback: the optical resonator laser power and threshold condition confinement of beam within the resonator – stability condition.

Laser output: Absorption and emission - shape and width of broadening lines – line broadening mechanisms – natural, collision and Doppler broadening.

Types of Lasers: Ruby laser, He-Ne Laser, CO_2 laser, Semiconductor GaAs laser, applications of lasers.

UNIT –III Non linear Optics and Holography

Basic Principles- Harmonic generation – Second harmonic generation- Phase matching –Third Harmonic generation-Optical mixing –Parametric generation of light –Parametric light oscillator-Frequency up conversion-Self focusing of light.

Introduction to Holography-Basic theory of Holography-Recording and reconstruction of Hologram-Diffuse object illumination-Speckle pattern –Fourier transform Holography-Applications of Holography.

UNIT-IV Fiber Optics

Fiber Optics : Introduction – total internal refraction –optical fiber modes and configurations- fiber types – rays and modes- Step index fiber structures – ray optics representation – wave representation – Mode theory for circular wave guides- wave guide equations – wave equations for step indexed fibers – modal equation – modes in step indexed fibers – power flow in step indexed fibers . Graded indexed fiber structure : Structure – Numerical aperture and modes in graded index fibers- Signal degradation in optical fibers – attenuation – losses – absorptive scattering – and radiative – core cladding – Signal distortion in optical wave guides – Information capacity determination – Group delay – Material dispersion – wave guide dispersion – inter modal dispersion – pulse broadening . Preparation of different techniques of optical fibers

Reference Books:

1. Introduction to Electrodynamics , D.J.Griffiths, Prentice-Hall, India
2. Electromagnetics, B.B.Laud, Wiley –Eastern, New Delhi.
3. Modern Optics, Fowels
4. Laser and their applications, M.J.Beesly, Taylor and Francis, 1976.
5. Laser and Non-Linear Optics, B.B.Laud, Wiley Eastern Ltd.,1983.
6. Optics , E.Hecht, Addison Wiley, 1974.
7. Optical fibers communications, Gerel Keiser, McGraw Hill Book, 2000.

NOTE : Question paper contains 5 questions. **FOUR** questions with internal choice have to be set from each unit. The 5thquestion has 4 short answers question covering units I to IV and any two be answered.

M.Sc. (IV Semester)
Paper-II Molecular and Solid State Spectroscopy PHY 4.2 (09)

UNIT -I

Molecular States : Molecular Quantum numbers and classification of electronic states. Hund's coupling cases 'a' and 'b'. Symmetry adapted linear combination (SALC) of atomic orbitals of individual atoms and the resulting molecular orbitals, electronic configuration and ground states of linear molecules H_2 , C_2 , N_2 ,O_2 and CO_2 and non-linear molecules H_2CO and H_2O . Symmetry properties of electronic and rotational levels.

ROTATIONAL SPECTROSCOPY: Microwave spectrum of a diatomic molecule. Rigid rotator and non-rigid rotator approximations. The effect of isotopic substitution. Vibrational satellites . Moment of Inertia and bond lengths of diatomic and linear triatomic molecule. Quantum theory and mechanism of Raman scattering. Rotational Raman spectra.

UNIT-II

VIBRATIONAL SPECTROSCOPY: The vibrating-rotating diatomic molecule. Harmonic and anharmonic oscillator energy levels. Evaluation of rotational constants from Infrared spectra .Evaluation of rotational constants from Raman vibration–rotation spectra..

ELECTRONIC SPECTROSCOPY OF DIATOMIC MOLECULES:

Vibrational analysis of an electronic band system of a diatomic molecule. Progressions and sequences. Deslandres table and vibrational constants. Isotope effect in vibrational spectra and its applications.

UNIT-III

NMR Theory, Basic Principles, Nuclear spin and Magnetic moment, Relaxation mechanism, spin lattice and spin-spin relaxation(12) times by pulse methods, Bloch's equations and solutions of Bloch's equations – Experimental methods, CW NMR Spectrometer.

Electron Spin Resonance – The ESR spectrometer, experimental methods, thermal equilibrium and Relaxation methods, characteristics of g and A values, Unpaired electron, fine structure and Hyperfine structure.

UNIT IV

Nuclear quadrupole resonance (NQR) spectroscopy, The fundamental requirements of NQR spectroscopy, General principles, Integral spins and Half Integral Spin., experimental detection of NQR frequencies, block diagram of NQR spectrometer, Experimental methods of SR oscillator, CW oscillator, pulse methods.

Mossbauer spectroscopy: The Mossbauer Effect, Recoil less Emission and Absorption, The Mossbauer spectrometer, Experimental Methods, Chemical shift, Magnetic Hyperfine interactions.

Photo Electron Spectroscopy, its theory, instrumentation and Applications.

Books:

High resolution Spectroscopy (Butterworths) J.M.Hollas.
Molecular spectra and Molecular Structure (van Nostrand) – G.Herzberg
Introduction to atomic spectra – H.E. White(T)
Fundamentals of molecular spectroscopy – C.B.Banwell (T)
Nuclear Magnetic Resonance By E R Andrew, Cambridge University Press 1955
Spectroscopy by B.P. Stranghon and S.Walker Volume 1 John Wiley and Sons Inc., New York, 1976
Pulse and Fourier transform NMR by TC farrar and ED Becker, Academic Press 1971
Mossbauer Spectroscopy – M.B. Bhide.

NOTE : Question paper contains 5 questions. **FOUR** questions with internal choice have to be set from each unit. The 5thquestion has 4 short answers question covering units I to IV and any two be answered.

M.Sc,.(IV Semester)

Paper-III **Condensed Matter Physics-III** **PHY 4.3A**

Unit-I

Classification of Materials: Types of materials, Metals, Ceramics (Sand glasses) polymers, composites, semiconductors.

Metals and alloys: Phase diagrams of single component, binary and ternary systems, diffusion, nucleation and growth. Diffusional and diffusionless transformations. Mechanical properties. Metallic glasses. Preparation, structure and properties like electrical, magnetic, thermal and mechanical, applications.

Unit-II

Glasses : The glass transition - theories for the glass transition, Factors that determine the glass-transition temperature. Glass forming systems and ease of glass formation, preparation of glass materials.

Applications of Glasses: Introduction: Electronic applications, Electrochemical applications, optical applications, Magnetic applications.

Unit-III

Biomaterials - Implant materials: Stainless steels and its alloys, Ti and Ti based alloys, Ceramic implant materials; Hydroxyapatite glass ceramics, Carbon Implant materials, Polymeric Implant materials, Soft tissue replacement implants, Sutures, Surgical tapes and adhesives, heart valve implants, Artificial organs, Hard Tissue replacement Implants, Internal Fracture Fixation Devices, Wires, Pins, and Screws, Fracture Plates.

Unit-IV

Liquid Crystals: Mesomorphism of anisotropic systems, Different liquid crystalline phases and phase transitions, Few applications of liquid crystals.

Nanomaterials

Different types of nano crystalline materials: nano crystalline metals, nano crystalline ceramics, Mesoporous materials, Carbon nanotubes, nano-coatings, zeolites, quantum dot lasers, nano structured magnetic materials; Synthesis of nanomaterials: Vacuum synthesis, sputtering, laser ablation, liquid metal ion sources, Gas-Phase synthesis, condensed-phase synthesis Characterization methods: XRD, SEM, TEM and AFM Properties of Nanostructure materials, Electrical and mechanical properties Optical properties by IR and Raman spectroscopy. Applications of nanomaterials

Text books

1 Inorganic solids D. M. Adams (John-Wiley)
2 Physics of Amorphous Materials by S.R.Elliott.
3 Phase transformation in metal and alloys, D. A. Porter and K. E. Easterling
4 Fundamental of thermotropic liquid crystals deJen and Vertogen
5 Nanocrystalline materials- H. Gleiter
6 . Biomaterials Science and Engg. J.B. Park
7. Materials Science and Engg. – C. M. Srivastava

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M.Sc. Physics (IV Semester)

Paper IV **: Condensed Matter Physics -IV** **PHY 4.4A**

UNIT I

Lattice Dynamics and Optical properties of Solids

Inter atomic forces and lattice dynamics of simple metals, ionic and covalent crystals. Optical phonons and dielectric constants. Inelastic neutron scattering. Anhormonicity, thermal expansion and thermal conductivity. Interaction of electrons and phonons with photons., Direct and indirect transitions.

UNIT II

Crystal growth techniques: Bridgeman-Czochralski-liquid encapsulated czochralski (LEC) growth technique-zone refining and floating zone growth-chemical vapour deposition (CVD)-Molecular beam epitaxy(MOVPE)-vapour phase epitaxy-hydrothermal groth-Growth from melt solutions-Flame fusion method.

UNIT III

Absorption in insulators, Polaritons, One – phonon absorption, optical properties of metals, skin effect and anomalous skin effect. Interaction of electrons with acoustic and optical phonons, polarons.

UNIT IV

Superconductivity: The Meissner effect –- Isotope effect- specific heat-thermal conductivity and manifestation of energy gap. Quantum tunnelling-Cooper pairing due to phonons, BCS theory of superconductivity, Ginzsburg-Landau theory and application to Josephson effect: d-c Josephson effect, a-c Josephson effect, macroscopic quantum interference. Vortices and type I and type II superconductors, applications of superconductivity-high temperature superconductivity (elementary).

Text and Reference Books

Madelung : Introduction to Solid State Theory.
Callaway : Quantum theory of Solid State.
Huang : Theoretical Solid State Physics

Kittel : Quantum theory of Solids
Solid state Physics by Guptha Kumar and Sarma
Solid State Physics S.O.Pillai New Age International

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