C = Core S = Special E = Elective

SEMESTER – I

MATHEMATICAL PHYSICS PHY101C

Linear Differential Equations:
Second order linear differential equations; Regular , regular singular and singular points; series expansion method; Bessel, Legendre, Hermite and Laguerre differential equations with properties of their solutions.

Integral transforms:
Laplace transform, Fourier theorem, Fourier transforms, Dirac delta function, Green's function, Green's function for Laplace operator. Solution of Poisson's equation. Inhomogeneous Wave equation and applications.

Complex Analysis:
Analytic functions, Cauchy-Riemann equations, Cauchy's theorem, Cauchy's Integral formula, Laurent series, Poles, Residue theorem,
Evaluation of integrals.

CLASSICAL MECHANICS PHY103C

Variational Principles and Langrange's Eqations:
Hamilton's principle, Calculus of variations, Langrange's equations , Conservation Theorems and symmetry properties.

Hamiltonian formalism:
Legendre transformations and the Hamiltonian Equations of Motion,Cyclic coordinates.
Canonical Transformations:
Canonical transformations , Poisson Bracket
Hamilton – Jacoby Theory:
Hamiltonian Jacoby equations ; Hamiltonian Jacoby theory, geometrical optics and wave mechanics
Small oscillations and normal modes:
Small oscillations about a stable equilibrium , Normal modes and their frequencies.

Langrangian and Hamiltonian formalism of Classical Fields.

ELECTROMAGNETIC THEORY PHY105C

Guided electromagnetic waves:
Transmission Lines and Wave Guides, Modes in a rectangular wave guide, Cavity resonators.

Tensor analysis:
General coordinate transformation; contravariant, covariant and mixed tensors; metric tensor; raising and lowering of indices; contraction of indices.

Minkowsky space and Lorentz transformations:
Geometry of space-time in Special Relativity; Minkowsky metric; Light cone and principle of causality; Invariance of Minkowsky metric under Lorentz transformations;Lorentz group; Proper, improper and orthochronous transformations; Pseudo-tensors.

Covariant formulation of electromagnetism:
Charge-current density four-vector; Scalar and Vector potentials; Gauge invariance; Electromagnetic potential four-vector; Electromagnetic field tensor; Lorentz transformation of electric and magnetic fields; Invariants of the electromagnetic field; Electromagnetic field of a charge moving with constant velocity, Covariant form of Lorentz force law; Dynamics of charged particles in static and uniform electric fields.

QUANTUM MECHANICS –I PHY107C

Foundations:
Dirac's Bra & Ket Notations, Hilbert Space, Vector Representations of States, Projection Operators, Observables as Operators, Orthonomality and Completeness of States, Relation between Ket and Wave-functions, Wave-functions in Coordinate and Momentum Representations, Matrix Theory of Harmonic Oscillator, Uncertainty Relations, Schrödinger, Heisenberg and Dirac Representations.

Angular Momentum:
Orbital Angular Momentum, Angular Momentum Algebra, Spin, Addition of Angular Momenta, Clebsch-Gordon Coefficients, Explicit Addition of Angular Momentum ½ with Angular Momenta ½ and 1, Spherical Harmonics in Central Field Problems, Spin-Orbit Coupling, Fine-Structure.

Second Quantization of Non-Relativistic Fields:
Non-Covariant Derivation of Lagrangian Equations for fields, Canonically Conjugate Momentum Density for Schrodinger Field, Quantum Conditions based on Commutation Relations and Second Quantization, Annihilation and Creation Operators, Second Quantization based on Anti-Commutation Relations, Simple Problems on Algebra of Annihilation and Creation Operators.

SEMESTER – II

QUANTUM MECHANICS –II PHY202C

Approximate Methods:
Time-Independent Perturbation Theory and Applications, Variational Method, WKB Method, Time-Dependent Perturbation Theory, Constant and Harmonic Perturbation, Transition probabilities, Fermi's Golden Rule, Semi-Classical Theory of Radiation, Einstein A and B Coefficients, Selection Rules, Scattering, Method of Partial Waves, Phase-Shifts, Born Approximation, Simple Applications.

Relativistic Quantum Mechanics:
Klein Gordon Equation and Free Particle Solution, Dirac Equation, Dirac Matrices, Covariance of Dirac Equation & Bilinear Covariants, Solution for a Free Particle, Negative Energy states and Hole Theory, Spin, Position Operator.

STATISTICAL MECHANICS PHY204C

A review of Gibbs ensembles, Partition function for Perfect Gas and ensemble of Harmonic Oscillators, Partition Function for Gases containing Monoatomic, Diatomic and Polyatomic Molecules. Grand partition function, Grand potential, FD and BE distribution in Grand Canonical ensemble
Degenerate Bose Gas, Momentum Condensation, Liquid He II, Two fluid theory, Sperfluidity, Degenerate FD Gas, Conduction Electrons in a Metal.
Fluctuations , One dimensional Random walk, Gaussian Distribution, Fluctuation in energy in canonical ensemble and the concentration in Grand Canonical ensemble.
Random processes, Markoff process, Langevin Equation , Correlation functions, Fluctuations , Dissipation Theorem, Weiner-Khintchine theorem, Nyquist theorem, Conditional probability, Fokker Plank Equation, Brownian motion.

SOLID STATE ELECTRONICS PHY206C

P-N Junction Diode : Rectifier with LC Filter, Electronic regulator.
Bipolar Junction Transistors: h-parameters , inter conversion in different configurations, low frequency transistor amplifier, thermal stability and bias stabilization.
Field Effect Transistors: Small signal model and dynamic parameters, CS and CD amplifiers.
Multistage Amplifiers: BJT at high frequencies, frequency response of gain and phase shift, frequency response of RC coupled amplifier.
Feedback Amplifiers and Oscillators: Different negative feedback amplifiers, stability and Nychist criteria , sinusoidal oscillators , phase shift
and Wien's bridge oscillators, Crystal oscillator, astable multivibrator.
Power and Radio Frequency Amplifier: Large signal amplifier and distortions, push-pull amplifier, single and double tuned amplifiers.
Modulation: Frequency and phase modulation, frequency modulation

DeModulation: Frequency changing and tracking; AGC, AFC, FM detection , amplitude limiter, phase discriminator, ratio detector.

ATOMIC & MOLECULAR PHYSICS PHY208C

Quantum states of an electron in an atom
Spectrum of Hydrogen and Helium atom, fine structure
Spectra of Alkali atoms ;energy level diagrams Sharp, Principal, Diffuse and fundamental series.
Hyperfine structure.
Width of spectral lines.
Spectroscopic terms; LS & JJ couplings
Zeeman, Paschen Back & Stark effect
X-ray spectroscopy
Electron spin resonance, Nuclear magnetic resonance , chemical shift
Spectra of Diatomic Molecules
Rotational Spectra (rigid rotator and non rigid rotator model)
Vibrational Spectra (harmonic and enharmonic model)
Molecular Symmetric Top, Vibrating rotator
Isotopic shift
Raman Spectra (Quantum mechanical and classical approach)
Electronic Spectra-vibrational structure of band system, fine structure of the band systems.
Intensity distribution in band systems: Frank Condon principle

SEMESTER – III

CONDENSED MATTER PHYSICS Paper - I

Electron band theory: one electron band theories. Plane wave like and localized wave functions. Nearly free electron approximation. Elementary discussion of orthogonalized Plane Wave (OPW) and Pseudo potential methods.
Variation of Fermi energy in extrinsic semiconductors.
de-Hass-van Alphen effect experiment to investigate Fermi surface.
Superconductivity: Meissner effect, isotope effect, type I and II superconductors. Cooper pairs. Elementary ideas of BCS theory. Approximate estimate of transition temperature, superconducting energy gap , Measurement of energy gap by infrared absorption and electron tunneling methods, Elementary ideas about Josephoson effect and high T_c superconductors.

Ionic lattice in presence of infrared field, dielectric constant , L.S.T. relation, LO and TO modes.
Lattice defects: Frenkel and Schotty defects, colour centres, number of defects (vacancies) in equilibrium, Dislocations, edge and screw Burgers vector.
Ordered phases of matter, translational and orientational order, Quasicrystals, conducting polymers.
Diamagnetism, Langevin diamagnetic equation , Quantum theory of paramagnetism rare earth ions and iron group ions. Ferromagnetism, Curie temperature, Heisenberg model, Temperature dependence of saturated magnetization.

NUCLEAR PHYSICS Paper - II

Two body problem: Deuteron, n-n scattering, n-p scattering, p-p scattering, charge independence and charge symmetry of nuclear forces.
Nuclear Models : Shell Model, Extreme Single particle picture and angular momentum, magnetic moment, quadrupole moment of nuclei, Nuclear Isomerism, Collective model (qualitative discussion).
Nuclear Reactions: Compound Nucleus , Breit Wigner Formula, Direct Interaction.
Fundamental types of Interactions, General Classifications of Elementary Particles, Isospin, Strangeness ,Conservation Laws , Symmetries (C, CP, CPT), SU(3) and quark model
Nuclear Decays: Alpha, beta and gamma decay
Heavy Ion Reactions, Relativistic Kinematics

Special Papers

CONDENSED MATTER PHYSICS

Paper - III

Ewald's method, Lorentz field

Phonons in perfect-crystals :

General theory of lattice dynamics of non-primitive lattice, normal coordinate description, quantization of lattice vibrations, phonon concept, ionic crystals, shell model. Inelastic scattering of slow neutrons by crystals for study of phonons. Kramer-Kronig relation.

Paper – IV

Dielectric constant of ionic crystals. Static polarizability, polarizability in variable field, placzek's approximation, first order Raman scattering, second-order Raman scattering, elementary ideas of the study of phonons by Raman scattering Plasmons, interaction of electromagnetic waves with phonons and polaritons.

Excitation in imperfect crystals :Definition of classical Green functions, application to one dimentional harmonic oscillator, principle of causality. Double-time quantum Green functions, correlation functions, spectral density.

Static Green function(Fourier transform), application to lattice vibrations and electron energy states. Point defect in one-dimensional lattice, localized, gap and resonance modes. Elementary ideas of extension to impurity electron energy states, gap states.

ELECTRONICS

PAPER – III: Analog and Digital Electronics

Wide band amplifier: Review of BJT at high frequencies. Hybrid pi-equivalent model, Junction capacitance, Base spreading resistance, Laplace Transform. RC Amplifier (CE BJT case only), transient response using Laplace Transforms. Effect of an emitter bypass capacitor on low frequency response. High and low frequency compensations.

Operational Amplifier: Ideal opamp. Emitter coupled differential amplifier. CMRR, Effect of constant current source IC op amp (emitter follower, level translation and out put device). Off – set error voltage and current and there balancing circuits. Temperature drifts, measurement of opamp parameters.

Linear Analog System: Basic Opamp Applications: Inverter, Scale changer, phase shifter, adder, voltage to current converter, current to voltage converter, d.c. voltage follower, differential dc and bridge amplifier, a.c voltage follower, analog integration and differentiation, analog compensation, solution of simultaneous and differential equations upto second order, amplitude and time scaling. Active filter Butter worth filter, active resonant band pass filter.

Non – linear Analog System: Comparators, sample and hold circuits, AC/DC converters and detectors, log and antilog amplifiers, log multiplier, wave form generator, regenerative comparator.

Digital Electronics (TTL Based): Review upto combination logic. Flip Flop: D,SR, JK, Master slave JK Register and counters: Shift Register, ripple counter, up down ashynchronous and synchronous counters, ring counter and sequence generators.

PAPER – IV: Microwaves

Cylindrical W/G, two conductor system and TEM mode, discontinuity reflection coefficient and SWR, Scattering coefficients of multiple junction, directional coupler, hybrid T, cylindrical cavity resonator ; S.O. of a cavity resonator, wave meter, attenuator, slotted line, magnetic properties of Ferrites, Faraday rotation, Gyrator and Isolator, Microwave Integrated circuits.
Vacuum Tube Microwave Generators :

Velocity modulation and density modulation, small signal theory of bunching, two cavity klystron amplifier and multiplier, two cavity klystron Oscillator : Reflex klystron : Theory of bunching, optimum power, effect of repeller voltage, electronic admittance, efficiency, electronic admittance, efficiency, electronic tuning.

Magnetron : Travelling wave magnetron, modes of Oscillations, output power.

Travelling wave tube : Description, dynamic of electron beam, coupling of beam and slow wave structure, waves in periodic structure, TWT amplifier and BWO, Generation of mm waves.

Microwave Measurements: Power, frequency, VSWR, Impedance, dielectric permittivity, Network Analyzer and scattering coefficients.

LASER AND SPECTROSCOPY

Paper – III: Laser Spectroscopy

Spectroscopic Radiation Sources & their Characteristics: Line light Sources (Arc, Spark, Discharge, Beam Foil etc.), Synchrotron, Laser.
Detection of Light: Thermal and Direct Photo Detectors, Optical Multichannel Analyzer Charged Coupled Devices(CCD), Integrated Charged Coupled Devices (ICCD).
Type of Laser: YAG, Argon Ion, Excimer, Dye, Semiconductor, Fixed Frequency and Tunable Lasers.
Types of Spectroscopy: Laser Raman Spectroscopy (CARS, SRS, SERS), Laser Induced Fluorescence (LIF), Laser Photoaccoustic Spectroscopy, Laser Optogalvanic Spectroscopy, Laser Isotope Separation, Fourier Transformation Spectroscopy, Time Resolved Spectroscopy. Medical Applications of Laser.

Paper – IV: Electronic Spectra of Diatomic Molecule

Review of electronic spectra of diatomic molecules, Deslander's table, Franck Condom Principle, Thermal Distribution of quantum state's, Intensity of molecular band in electronic spectra. Effect of nuclear spin on the intensities of fine structure of electronic bands.

Classification of Molecular States, Multiplet Structure, Coupling and Uncoupling phenomena, Selection Rules for Electronic Transitions, Building up Principles. Electronic Configuration in diatomic molecule, Molecular Orbital Theory.

Basic concept of continuous and diffused spectra, Determination of heats of dissociation.

NON-LINEAR OPTICS

Paper III: Coherence Theory and Elementary Nonlinear Optics

Representation of Polychromatic Field by Analytic Signal. Mutual and Self Coherence Functions. Degree of Coherence, Van Cittert Zernicke Theorem, Degree of Coherence of Thermal Circular Thermal Source, Relationship of Spectral-Profile with Correlation Functions.

Nonlinear Interaction of Light with Free Electrons: Free Electron in Plane Electromagnetic Wave, Drift Acceleration of Electron, Second Harmonic Generation in Scattering of Plane Electromagnetic Wave (elementary discussion)

Nonlinear Interaction of Light with Material Media: Nonlinear Polarization, Classical Model of an Anharmonic Oscillator, Nonlinear Susceptibilities and Miller's Rule. Simple explanation of Kerr Effect, Elementary Discussion of Harmonic Generation in Dielectric and Phase Matching. Elementary discussion of Self-Focussing and Self-Steepening.

Paper IV: Quantum States of Radiation

Coherent States of Radiation. Coherent State as wave packet, Expansion of States and Operators in Terms of Coherent States. Density Operator of Radiation. Sudarshan-Glauber Representation, Density Operators of Coherent and Chaotic Radiation. Polarization and Stokes Parameters, Annihilation and Creation Operators for Modes with General Polatrization. Unpolarized Light.

Photoelectron Counting Distribution, Hanbury Brown and Twiss Experiment, Bunching and Antibunching , Example of pure Fock State for Antibunching of Photons, Schwartz Inequalities and Quantum Behaviour of Optical Fields, Squeezed States of Radiation (Elementary Discussion)

X-RAY AND ION BEAM

Paper- III: (X-RAY PHYSICS AND INSTRUMENTATION):

General X-Ray Physics: Energy spectrum, continuous and characteristic X-ray spectra. Kramers theory of production of X-rays by thin and thick targets. Dispersion theory and

refraction of X-rays. Theory and observation of photoelectric effect and secondary Spectra. Screening doublets and X-ray energy level diagrams. Forbidden lines. Relative intensities of X-ray lines, Theory of fine structure of absorption edges and absorption discontinuity.

X-Ray Generators: Types of X-ray tubes and auxiliary equipment. Sealed source, rotating anode, and synchrotron, Detection of X-Rays: Photographic and electronic detectors

X-Ray Spectroscopic Techniques: One crystal, bent crystal, double crystal spectrometer and ruled gratings in X-ray spectroscopy. Soft X-rays spectroscopy and valence band spectra, XPS, AES, EXAFS, XANES.

Paper- IV: (BEAM PHYSICS AND INSTRUMENTATION)

General Concepts: Emittance and brightness, Effects of space charge in charged particle sources. Interaction of particles with matter, cross section, survival probability, free path length, energy loss of heavy particles.

Beam Sources: Survey of beam sources and some applications: Ion extraction and focusing geometries, positive & negative ion sources, radio frequency sources, ECR-source, atomic/molecular beam sources. Overview of accelerator types, beam manipulating elements, beam acceptance, betatron motion, lattice functions, tune, phase stability, luminosity, beam cooling, representative examples of accelerators.

Detection and Controls systems: Transition radiation, detector characteristics (sensitivity, response, efficiency, dead time), gas detectors, calorimeters, semiconductor detectors, Cerenkov counters, scintillating chambers, interface buses for control instrumentation, CAMAC, current trends in data acquisition, Interpolation, concept of error propagation, Gaussian quadrature, Monte-Carlo method, Signal to noise ratio, pulse shaping and amplification, pulse height and timing measurements

NUCLEAR AND PARTICLE PHYSICS

Paper – III: Advanced Nuclear and Particle Physics – I

Review of Theoretical Techniques: Rotational invariance in 3-dimesions, eigen values and eigen functions of angular momentum operators, addition of angular momenta, C.G. coefficients. Spherical tensors, Wigner Eckart theorem and its applications. Occupation number representation, calculation of the matrix element of one-and-two body type symmetric operators.

Nuclear Shell Model: Common potential V(r) in spherical shell model, wave function, quantum numbers. Two-particle outside a closed core, residual interaction and configuration mixing, effective interaction and operators. Transformation to center-of-mass and relative coordinates, Moshinsky transformation brackets, energy level

calculations. Spectra of closed shell nuclei, lp-lh excitations, three or more particles outside a closed core, coefficient of fractional percentage. Shell model Monte Carlo methods

Collective models: Nuclear vibrations, isoscalar vibrations, sum rule in vibration model, Giant resonances. Collective model of Bohr and Mottelson, back bending, high spin states, superdeformed and hyperdeformed shapes. Particle states in nonspherical nuclei-Nilsson's model, coupling of particle states and collective motion in unified model

Mean Field models: Nuclear mean field, Hartree-Fock theory, Hartree-fock Bogolieubov , Pairing plus quadrupole interactions.

Paper IV: Advanced Nuclear and Particle Physics – II

Symmetries and conservation laws, Noether theorem, Parity, Charge Conjugation and Time Reversal, CPT theorem, G-Parity, SU (2) of isospin, SU (3) and the quark model, meson and baryon spectra.

Elementary particles as fields, Recapitulation of the quantization of free, scalar and electromagnetic fields, Dirac equation, helicity and chirality, quantization of Dirac fields.

Interaction Hamoltonian in normal form, chronological products, Wicks theorem, S-matix formulation, Feyman digrams, propagators, Feynman rules, Compton scattering, Particle accelerators, fixed targets and colliding beam experiments, basic ideas of particle detection, discovery of J/ψ.

SEMESTER - IV

EXPERIMENTAL TECHNIQUES & CONTROL SYSTEMS **Paper - I**

Data Interpretation and Analysis: precision and accuracy, error analysis, propagation of errors, least squares fitting, linear and non linear curve fitting, chi-square test.

Optoelectronic Devices and Detectors: Solar cells, Photodetector, Transducers (Temperature , Pressure, Vacuum pumps and Gauges)
Measurement and Control systems: Signal conditioning and recovery impedance matching. Ideal operational amplifier, characteristics and applications; Inverting and non inverting amplifier, integrator, differentiator, adder and comparator.
Analogue v/s digital data:
Statement of sampling theorem, A/D converters (Flash converters, single slope, double slope and successive approximation converter), D/A converter(R-2R ladder type and weighted resistor type converter), Digit filter (tapped delay line filter), Fourier Transforms and lock-in detector, Box car averaging. Microprocessor and microcontroller basics, Instruction set related MOV, MVI and I/O commands. Addressing I/O devices (Memory mapped & I/O mapped I/O)

ELECTIVE PAPER **Paper - II**

Elective – I

PROGRAMMING FOR NUMERICAL METHODS

C++ keywords: various data types, implicit conversions, for loop, while and do- while loop. break and continue statements, switch statement, if else , conditional operator, functions with default arguments, function overloading
++ and – operators, Arrays, Structures, Pointers, Compound assignment.

Basic concept of OOP: definition of class and object, declaration of classes and objects, simple applications.

Programming in C++ for the following:

1. Newton Raphson method , Iterative method
2. Integration by Trapezoidal and Simpson 1/3 rule
3. Interpolation.
4. Matrix manipulations
5. Euler's method, Runge kutta (second order and fourth order) method, phase space trajectory, equilibrium points, stability analysis.

Elective – II

ELECTROYNAMICS AND SECOND QUANTIZATION

Radiation from a Moving Charge:
Solution of Inhomogeneous Wave equation, Greens Functions, Lienard Wiechert Potentials and Field from a moving charge, Larmor's formula and its Relativistic Generalization, Angular Distribution of Radiation from an Accelerated Charge, Electromagnetic Field and Radiation from an Oscillating Localized Source.

Radiation Reaction and Self-Force:
Radiation Reaction Force from Conservation of Energy, Line Width and Level Shift of an Oscillator.

Lagrangian and Hamiltonian Formalisms for Fields:
Covariant Lagrangian Formalism, Noether's Theorem, Energy-Momentum Angular Momentum and Spin Tensors, Current Density Four Vector.
Second Quantization:
Second Quantization of Scalar field and of Electromagnetic Field in Radiation Gauge and of Dirac Field, Spin of Photons, Simple Problems on Algebra of Annihilation and Creation Operators.

Elective - III

GROUP THEORY

Group theory and its application: Abstract definitions: Group, Multiplication Table, Sub-groups, Isomorphism and homomorphism, complexes, Cosets and classes, Indirect-group, Direct product of groups.
Theory of Representation :Linear vector space, basis, matrix representation of operators, unitary space, Unitary matrices, representation of group, characters, reducible and irreducible representations, Invariant subspaces, Schur's Lemmas, Orthogonality theorem for irreducible representation and characters. Regular representation, occurrence of, an irreducible representation in a reducible representation. Theorem for possible number of irreducible representations of a group. Direct product of representations.
Relationship to Quantum mechanics: Symmetry transformations, degeneracy and invariant subspaces, projection operators, transformation of functions.

Applications to molecular and crystal symmetry, Fundamental point group operations and nomenclature, construction of thirty-two point groups and character tables for their irreducible representations.

CONDENSED MATTER PHYSICS

Paper – III

Transport Theory : Phenomenological coefficient L_{ij} and their physical interaction. General Boltzmann equation and its linearization Entropy production. Relaxation time solution of Boltzmann equation. Electronic contributions of thermal and electrical conductivities and to Peltier, Seeback coefficient for metals and electronis semiconductors. Relationship between electrical and ideas about lattice contribution to thermal conductivity.

Magnetism :Classical and Semi Classical Theories : Failure to explain large internal fields. Exchange interaction. Ising Model. Bragg William Approximation. Explanation of lerge external fields. Non-existence of ferromagnetism in two-dimensional Ising Model. Two sub-lattice Model and classical theories of antiferromagnetism and ferrimagnetism, Ferrites and garnets.

Second Quantized Theory : Ferromagnetic Hiesenberg Hamiltonian, Holstein-Primakoff transformations and their application to Heisenberg Hamiltonian for small fractional spin reversal. Ferromagnetic magnons, Magnon heat capacity and saturation magnetization at small temperatures. Antiferromagnetic Hamiltonian and its reduction using Holstein Primakoff transformation, Antiferromagnetic magnons. Zero point sub-lattice magnetization.

The Magnetic Phase Transition :Order parameter, Landau's theory of second order phase Transitions. Fluctuations of the order parameter. Elementary qualitative ideas about critical exponents and scaling.

Paper – IV

Many Electron Systems :Second quantization for Fermions, field operators, electron density operator, Hamiltonian for two particle interactions in second quantized form : Coulmbian interacton and screened Coulombian interacton.

Linear Response Theory : Dielectric response analysis, dielectric constant for electron gas in self consistent approximation, Lindhard formula, dielectric constant. Dielectric screening of a point charge impurity.

Electron-Phonon Interaction : Long wavelength limit, deformation potential interaction, Born approximation, deformation potential perturbation Hamiltonian, Normal processes, polaron. Number of phonons accompanying electron. Electron-electron interaction via phonons, Attractive interaction, Cooper pairs, Reduced Hamitonian for superconducting state. Bogoliubo-Valatin tranformation, Diagonal and non-diagonal terms, superconducting ground state energy, nature of ground state, excited states, Temperature dependence of energy gap, Transition temperature, Simple treatment of Meissner effect and flux quantization.

ELECTRONICS

PAPER – III: Microprocessor

Microprocessor: Microprocessor 8085, Instruction set, Simple programs, Memory organization and mapping, I/O devices Chip select and interfacing in I/O mapped and memory mapped I/O schemes. Hardware description of 8085.

PIA 8255 Handshaking via interrupt and polling, CMOS devices as RAM and ROM. Memory refresh. A to D and D to A converter, IC ADC0809 and DAC08, Pin Out their interfacing with 8085.

PAPER – IV: Electronics : Semiconductor Devices

Semiconductor Physics: Carrier concentration in intrinsic and extrinsic semiconductors, recombination process, current density and continuity equations, decay of photo excited carrirs, steady state injunction, transient and steady state diffusion.

P-n junction diode :

Junction and diffusion capacitance, diode equation, break downs, temperature dependence of voltage and current. Varactor diode and parametric conversion and amplification, Tunnel diode, V-I characteristics, tunnel diode as an amplifier and as an oscillator. Gunn diode, modes of operation, power and frequency performance. Impact: Static and dynamic characteristic, small signal analysis and negative conductance, power and frequency performance, device design and performance. Schottky effect and Schottky diode.

BJT :Current voltage relations in active, cut off and saturation regions, microwave transistor, cut off frequency, device geometry and performance.

LASER AND SPECTROSCOPY

Paper – III: Advanced Atomic Spectroscopy

Lamb – shift in hydrogen spectrum, Rydberg atoms and Rydberg states, Complex Spectra and their interpretation, nitrogen, oxygen and manganese as examples, Alternation of multiplicities, Inversion of states, Breit's Scheme for spectral term derivation.

Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES), Inductively Coupled Plasma Mass Spectroscopy (ECP-MS) Photo electron spectroscopy (PES), Auger Electron Spectroscopy (AES), X-Ray Fluorescence Spectroscopy (XRF).

Limitations of Optical Microscope and Electron Microscope, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Electron Microscopy (STEM), Fluorescence Microscopy.

Paper – IV: IR & Raman Spectra of Polyatomic Molecules

Symmetry Elements and Symmetry Operations, Point Groups, Classification of Molecules into Point Groups.

Rotation and Rotational Spectra of Linear Polyatomic Molecules and Symmetric Top Polyatomic Molecules, Energy Levels and Symmetry Properties, Influence of Nuclear Spin and Statistics, Rotational Structure in the Far Infrared, Rotational Structure in the Raman Spectra & Alteration of Intensity.

Vibrational Motion, Motion in Cartesian Coordinates, Mass Weighted Cartesian Coordinates, Normal Coordinates and Normal Modes of Motion; Vibrational Energy, Infra-red and Raman Vibrational Spectra, Fermi Resonance, Several Potential Minima and Inversion in Ammonia Molecule, Torsional oscillations, Active and Inactive IR and Raman Fundamentals, Functional Group Analysis.

Interaction of Rotation and Vibration, Rotation Vibration Spectra of Linear Polyatomic Molecule, Energy levels and Symmetry Properties, Coriolis Interaction, IR and Raman Spectra of Linear Polyatomic Molecule.

X-RAYS AND ION BEAM

Paper - III: (Geometrical X-Ray Diffraction)

Symmetries and classification of crystals. Point groups and space groups. Bragg's Law, Reciprocal lattice, Ewald Construction, Laue equations, Temperature effects. Scattering of X-Rays by electron, Lorentz polarization factor, Atomic scattering factor, Diffraction by a composite lattice, integrated reflection from mosaic and perfect crystal.
Powder diffraction, Laue, Rotation, Oscillation and Weissenberg methods. Crystal structure analysis, Fourier method, phase problem, Patterson function.
Diffuse scattering of X-rays by gases, liquids, polymers and Amorphous materials, Low angle scattering, Electron and neutron diffraction, X-ray study of order-disorder phenomena.

Paper - IV: (Ion Beams Induced Modification and Characterization Techniques)
GENERAL CONCEPTS AND THEORETICAL BACKGROUND**:** Energy loss of Mev Ions in Solids: Interaction of a particle with a free electron gas, local density approximation in stopping power theory, electronic stopping cross section. Nuclear and Electronic energy loss. Theories of Energy transfer from Ion to matter: Thermal Spike, Coulomb Explosion, Lateral Mass Transport. Simulation of range distribution by Monte-Carlo methods (SRIM/TRIM).

Ion implantation, radiation damage and structure change, ion beam mixing, radiation enhanced diffusion, diffusion by vacancies, self-diffusion and impurity diffusion, impurity incorporation, silicide formation, RBS and Channeling, ERDA, NRA, PIXE etc.,

ION BEAMS IN DEVICE MAKING: Amorphous superstructure and hetero-junctions,

band discontinuities and local structure, ion induced amorphous to single crystal transition in silicon. Artificially structured materials, buried layers and band structural engineering for new functional devices, polymer. Special features of the super conducting state - magnetization M(H), specific heat, the energy gap. HTSC columnar defects and modification of super conducting properties. Conditions leading to formation of defects using ions and tuning the Band Gaps, Photo-luminescence and Iono-luminescence properties.

NON-LINEAR OPTICS

Paper III: Resonant Interaction of Atoms with Radiation - I

Homogeneous and Inhomogeneous Broadenings. Semi-classical Theory of Interactions of Two-Level Atoms with Radiation. Rotating Wave Approximation and Description by a Pseudo-spin Vector. Optical Block Equations. Comparison of Classical and Semi-classical Descriptions.

Elementary Ideas about Area of Pulses and Rabi solution of Optical Bloch Equations. Phenomenological Introduction of Decay Constants, Solution of Optical Bloch Equations and Elementary Applications. Elementary Ideas about Optical Nutation and Adiabatic Following.

Coupled Maxwell and Optical Bloch Equations. The Factorization Assumption. Elementary of Mc Call Hahn Area Theorem and Self-Induced Transparency.

Elementary Ideas about Photon Echo and its Direction

Paper IV: Resonant Interaction of Atoms with Radiation – II

Two-Level Model of Atoms, Atomic Spin Operators and States and their properties, Rotations in Atomic Spin Space and Elementary Ideas about Berry's Phase. Dicke's Collective Atom Operators and States, Degeneracy of Dicke States of an Assembly of Atoms, Holstein-Primakoff and Two-Boson Modes Representations of Dicke Operators and States.

Elementary Ideas about Entanglement of Two Two-Level Systems and their Use in Quantum Teleportation.

Schrodinger, Heisenberg and Interaction Pictures. Hamiltonian for Interaction of an Atom with Radiation. Relative Contributions of **p.A** and A^2 terms. Dipole Approximatiion, Rotating Wave Approximation, Weisskopf-Wigner Approximation, Welton's Treatment of Lamb Shift. Superradiance.

NUCLEAR AND PARTICLE PHYSICS

Paper – III : Advanced Nuclear and Particle Physics

Measurements Techniques and Data Processing: Interaction of charged particles and radiation with matter, experimental techniques in particle and gamma ray spectroscopy, gamma detector arrays, coincidence method, decay schemes, counters, statistics of counting, Poisson and Gaussian distribution, statistical quality of data, chi-square test. Nuclear Reaction: Compound nucleus model, Resonance, level density; decay, cross-section, entrance channel effect, Statistical theory, Pre equilibrium model, Direct reaction, Plane wave theory (Born approximation), general theory, examples of direct reactions, nuclear spectroscopy from direct reactions, Theory of average cross-section,

optical model, Heavy ion induced nuclear reactions, Features of medium and low energy heavy ion elastic scattering, diffraction model, Coulomb excitation.

Exotic Nuclei: Nuclear structure at the extremes of stability, proton and neutron drip lines, nuclear halos, neutron skins, proton rich nuclei and beyond, decay modes of exotic nuclei, RI B as a new experimental technique.

Paper – IV: Advanced Nuclear and Particle Physics

Basic relativistic kinematics, Mandelstam variables, Lorentz invariant phase space, cross section for $2\rightarrow2$ processes, decay width for $1\rightarrow2$ and for $1\rightarrow3$ processes, Lagrangian for electron-photon interaction, gauge invariance, $e^+e^-\rightarrow\mu^+\mu^-$, Weak interaction, parity violation and (V-A) theory, amplitude and calculation of decay width for pion and muon decays, Cabibbo angle, Brief overview of recent developments, qualitative introduction to deep inelastic scattering, parton model and quantum chromodynamics, Unification of weak and electromagnetic interaction, Salam-Weinberg theory, spontaneous symmetry breaking and Higgs mechanism, neutral currents.