M.Sc. (Physics)

M.Sc. (Previous) – First Semester	**Maximum Marks**
Paper -I: Mathematical Physics	50
Paper -II: Classical Mechanics	50
Paper -III: Quantum Mechanics-I	50
Paper- IV: Statistical Mechanics	50
Paper- V: Numerical Methods	50
Paper- VI: Solid State Electronics-I	50
Practical-I	150
M.Sc. (Previous)- Second Semester	
Paper-I: Relativity	50
Paper- II: Quantum Mechanics-II	50
Paper-III: Group Theory	50
Paper-IV: Atomic Structure	50
Paper-V: Electromagnetic Theory	50
Paper-VI: Solid State Electronics-II	50
Practical -II	150
M.Sc. (Final)- Third Semester	**Maximum Marks**
Core Papers	
Paper-I: Relativistic Quantum Mechanics	50
Paper-II: Solid State Physics-I	50
Paper-III: Nuclear and Particle Physics-I	50
Paper-IV: Molecular Structure	50
Elective Papers	
Electronics	
Paper-V: Analog and Digital Electronics	50
Paper-VI: Microwaves	50
Lasers and Spectroscopy	

Paper-V: Laser Spectroscopy	50
Paper-VI: Electronic Spectra of Diatomic Molecules	50

Material Science

Paper-V: Material Science I	50
Paper-VI: Material Science II	50
Practical-III	150

M.Sc. (Final)- Fourth Semester

Core Papers

Paper-I: Classical Electrodynamics	50
Paper-II: Solid State Physics-II	50
Paper-III: Nuclear and Particle Physics-II	50
Paper-IV: Data Acquisition System	50

Elective Papers

Electronics

Paper-V: Microprocessor	50
Paper-VI: Physics of Semiconductor Devices	50

Lasers and Spectroscopy

Paper-V: Atomic Spectroscopy	50
Paper-VI: IR and Raman Spectra of Polyatomic Molecules	50

Material Science

Paper -V: Material Science III	50
Paper-VI: Material Science IV	50
Practicals-IV	150

M.SC. PREVIOUS- I SEMESTER

Paper- I: MATHEMATICAL PHYSICS

Functions of complex variables, analytical function, Cauchy- Rlemann equation, Poles and residue, Cauchy's integral theorem, Cauchy's integral formula, Contour Integraton.

Second order linear differential equations, Boundary value problems, Sturm- Liouville problem, Legendre, Bessel, Hermite and Laguerre functions and their properties.

Application of the method of separation of variables to Laplace, Wave and Diffusion equations.

Paper- II: Classical Mechanics

Generalised co-ordinates, Eularian angles, Lagrange equations, Hamilton's equations, Calculus of variations, Euler- Lagrange equations, Hamilton's Principle, Canonical transformations, Poisson brackets, Jacobi identity, Canonical invariance of Poisson brackets.

Fourier Integral Theorem, Fourier Transform, Dirac-delta function, Green's function, Poisson equation.

Paper- III: QUANTUM MECHANICS- I

Dirac bra and ket notations, vector representation of state, bra and ket vectors, projection and projection operators, linear operators: eigenvalue equation, orthonormality and completeness relation, relation between kets and wave function, concept of Hilbert space. Elementary ideas of measurement of quantum mechanics.

Matrix theory of linear harmonic oscillator, general proof of Uncertainty Principle.

The equations of motion, constants of motion, Schrodinger, Heisenberg, Interaction representation.

Angular momentum, Ladder operators, Matrix elements of J_2 an d J_Z, Pauli spin matrices, coupling of angular momenta, Clebsch- Gordon Coefficients: (J_1= 1/2 , J_2= ½ and J_1= 1, J_2= ½ cases).

Quantization of non-relativistic Schrodinger equation, The number representation, creation and annihilation operators.

Paper – IV: STATISTICAL MECHANICS

Liouville Equation: A review of Gibbs ensembles, Partition function for ensemble of harmonic oscillators. Grand partition function. Grand potential, FD and BE distribution in Grand Canonical ensemble.

Degenerate Bose Gas, Momentum condensation, Liquid He II, Two fluid theory, Superfluidity.

Fluctuations, One-dimensional Random Walk, Gaussian distribution, Fluctuation in energy in Canonical ensemble and the concentration in Grand Canonical ensemble.

Random Processes, Markoff Processes, Langevin Equation. Correlation Functions. Fluctuations, Dissipation Theorem, Weiner-khintchine Theorem. Nyquist Theorem, Conditional Probability, Fokker-Plank Equation, Brownian Motion.

Paper- V: 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, Scope of variables, Reference variables, ++ and – -operators, Arrays, Structure, Pointers, Compound assignment.

Basic concept of OOP, Definition of Class and Object, Declaration of classes and objects in C++, Simple applications.

Programming in C++ for the following
Newton Raphsons method
Iterative method
Newtons forward and backward interpolation
Integration by Trapezoidal rule.
Integration by Simpson 1/3 rule.
Euler'sMethod
Modified Euler's method
Runge Kutta second order method
Runge Kutta fourth order method
Matrix manipulations

Paper- VI: SOLID STATE ELECTRONICS- I

P-N junction diode: Characteristics, temperature dependence of the characteristics, dynamic parameters, junction and diffusion capacitance, breakdown diodes, rectifiers, LC filter, Zener diode as voltage regulator, electronic regulator.

Bipolar Junction Transistors: Transistor action, configurations and characteristics, current gains, h-parameters and their inter conversions in different configuration, thermal instability and bias-stabilization, cascaded transistors.

Field Effect Transistors: Construction, operation and characteristics, 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 amplifiers.

M.Sc. PREVIOUS- II SEMESTER

Paper- I: RELATIVITY

Four -Dimensional Formulations: The space-time metric of special relativity. Metric tensor, Lorentz transformation, contravariant, covariant and mixed tensors, Raising and lowering of indices, contraction of indices, Pseudo tensors.

Lorentz Group: Homogeneous transformation, group property, Proper and improper transformations, Orthochronous transformation, Inhomogeneous Lorentz transformation.

Transformation Properties of Electromagnetic fields: Transformations of source densities, potential and fields,covariant form of Maxwell's equations, Invariants of Electromagnetic field. Electromagnetic field of a uniformly moving charge.

Paper- II: QUANTUM MECHANICS-II

Stationary Perturbation theory for degenerate cases, Time dependent perturbation theory, Constant and Harmonic perturbation, Transition probabilities, Variational method and its application to ground state energy of Helium.

Self-consistent field approximation (Hartree method), Slater determinant, Hartree-Fock method (general idea), Quantum theory of scattering, Scattering cross -section, Scattering by one dimensional potential barrier, Beta and alpha decay, Collisions in three-dimensions, Phase-shift analysis and its application to low energy scattering, Born approximation, Square well potential, Ground state of deuteron, screened Coulomb potential.

Paper- 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 Representations: 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 representation of a group. Direct product of representations.

Relationship to Quantum mechanics: Symmetry transformations, degeneracy and invariant subspaces, projection operators, transformation of functions.

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

Paper- IV: ATOMIC STRUCTURE

Spectra of one valence electron system, Fine structure of hydrogen atom spectrum and alkali atoms, Zeeman effect, Pashchen-Back Effect, Stark effect in hydrogen atom. Spin-orbit interaction for two valence electron system (LS and JJ coupling). Pauli's exclusion principle, Singlet and triplet states, Interpretation of Helium spectrum, Building up principle, Periodic Table of elements.

Breadth of spectral lines, effect of nuclear properties on spectral lines, X-ray spectra, Regular and irregular doublet law, iso-electronic sequences, Auto- ionization, Photoelectron Spectra, Auger Process.

Paper- V: ELECTROMAGNETIC THEORY

Electrostatics in Media: Effective field and Molecular Lorentz Field, Polarizability, Clausius- Mossoti equation, Lorentz-Lorentz relation. Evaluation of molecular polarizability for simple models, Debye equation and temperature dependence of dielectric constant.

Material equation and Maxwell's equations: Microscopic and Macroscopic fields, Macroscopic Maxwell's equations, Fields D and H. Dielectric tensor, Principal dielectric axes.

Potential and Gauges: Scalar and Vector potentials, Gauge transformation, Lorentz Gauge and Transverse Gauge, Maxwell's equations in terms of electromagnetic potentials.

Propagation of Electromagnetic waves in Crystals and Optically Active Media: Structure of monochromatic plane wave in an anisotropic medium, Fresnel's Formulae for propagation of light in crystals, Duality, Geometrical constructions, Ellipsoid of wave normal and ray ellipsoid, Propagation of light in uniaxial crystals.

Propagation of Electromagnetic waves in guided media: Transmission lines, Wave guide, modes of vibrations in a rectangular wave-guide, cavity resonators and quality factors.

Paper- VI: SOLID STATE ELECTRONICS- II

Feedback Amplifiers and Oscillators: Classification, different negative feedback amplifiers and their characteristics, stability and Nyquist criteria, Sinusoidal oscillators, phase shift and Wiens bridge oscillators, crystal oscillators, Astable multivibrator.

Power and Radio Frequency Amplifier: Large signal amplifier and distortions, transformer coupled audio power amplifiers, push-pull amplifier, single tuned amplifiers, double tuned amplifiers.

Modulation: Frequency Spectrum and Power in AM wave, AM modulating circuits, Frequency and phase modulation, frequency modulator.

Demodulation: Superhet detection, Frequency changing and tracking, detection and AGC, AFC, FM detection, amplitude limiter, slope detection, phase discriminator, radio detector.

LIST OF EXPERIMENTS FOR PRACTICAL I AND II

First Year: Electronics laboratory

A. Design and Study of Amplifier

1. Common Emitter Amplifier.
2. Common Base Amplifier.
3. Common Collector Amplifier.
4. Double Stage Amplifier.
5. Comparison of Amplifiers in CB, CE and CC configuration.

B. Study of Temperature Variation of Characteristics and Constants

6. BJT Characteristic and Constants
7. Bias-stabilization
8. Band Gap of Si and Ge Diodes

C. Study of Power Supply

9. Constant Voltage Power supply
10. Constant Current Power Supply
11. IC Controlled Power Supply

D. Design and Study of an Oscillator

12. Phase-Shift Oscillator
13. Tuned Collector Oscillator
14. Astable Multivibrator

E. Study of Device other thab BJT

15. Field Effect Transistor
16. Silicon Controlled Rectifier
17. Uni-Junction Transistor

F. Amplitude-Modulation and Demodulation

G. Negative Feedback

(b) Study of AM detector

GENERAL LABORATORY

1. Concave Grating, Hg source Arc
2. Optical Properties of Quartz
3. Cornu's fringes
4. Edser Butler fringes
5. Lummer-Gehrcke Plate- Wavelength difference and Normal Zeeman effect
6. Fresnel's formula
7. Fabry-Perot Interferometer
8. Metallic reflection-Refraction index and Absorption constant
9. Curie balance-Magnetic Susceptibility
10. Kerr effect-Ker cell
11. Stefan's Constant
12. Ultrasonic interferometer- Variation of velocity with temperature
13. Laser Intensity diffraction pattern of different objects
14. Lattice dynamics of Monoatomic and Diatomic lattices
15. Hall effect
16. Study of Total Internal Reflection

M.Sc. FINAL- III SEMESTER

Paper- I: RELATIVISTIC QUANTUM MECHANICS

Klien Gordon Equation, Interpretation, Free Particle Solution, Dirac Equation, Dirac Matrices, Covariant Form, Algebra of Dirac matrices, Covariance of Dirac Equation, Bilinear Covariants, Non Relativistic Correspondence, Solution for a free particle, Negative Energy state and Hole Theory, Spin, Zitterbewegung and Foldy-Wouthuyson transformation.

Lagrangian and Hamiltonian Formalisms for Fields: Derivation of Lagrangian and Hamiltonian equations. Symmetry transformations and conservations law, energy-momentum, Angular Momentum and Spin tensors, Current-Density four vector.

Second quantizations: Second Quantization of Scalar Field and Dirac Field, Second Quantization of Electromagnetic Field in Radiation Gauge, Spin of Photon, Simple Problems on Algebra of Annihilation and Creation Operators.

Paper- II: SOLID STATE PHYSICS-I

Lattice Dynamics: Central and Non-central forces, generalized force constants, Harmonic approximation, Three-dimensional lattice, Equation of motion and solution in terms of dynamical matrix, normal modes, acoustics and optic modes along with polarizations, Frequency Distribution in one and three dimensions, Ionic lattice in presence of infrared field, dielectric constant, L.S.T. relation, LO and TO modes, reflectivity of ionic crystals.

Mossbauer effect: Recoil energy in an isolated atom, recoilless emission and reabsorption, zero phonon lines in gamma ray emission and X-ray diffraction, intensity of zero phonon line, conditions for the observation of Mossbauer effect, experimental set up, application in nuclear hyperfine structure.

Magnetism: Paramagnetism, Brillouin Langevin theory, application to the rare earth and iron group metals, quenching of orbital angular momentum, Molecular field theory of ferromagnetism, exchange interaction between spins, Heisenberg Hamiltonian, spin waves in one dimension, quantization of spin waves (simple treatment), ferromagnetic and antiferromagnetic order, neutron diffraction method to obtain magnetic order in ferromagnetic and antiferromagnetic magnons, temperature variation of magnetization in garnets.

Lattice defects: Point defects, Frenkel and Schottkey defects, color centres, thermal and configurational entropy. No. of defects (vacancies) in equilibrium, Dislocations, edge and screw, Burgers vector.

Paper- III: NUCLEAR AND PARTICLE PHYSICS-I

Binding Energy, Basic Properties of nuclei, Weizsacker mass formula, nuclear stability, nuclear size by electron scattering, nuclear matter (elementary discussion only).

Two nucleon problem at low energies: Ground state of deuteron, n-p scattering analyses by method of partial waves, effective range theory, effect of chemical binding, spin dependence, scattering of neutrons by ortho and para- hydrogen, p-p scattering, charge independence and charge symmetry.

Nuclear Forces: Non-central force, Deuteron in the presence of non-central force. Exchange forces, isospin and charge independence, pion theory of nuclear forces (elementary treatment).

Paper- IV: MOLECULAR STRUCTURE

Quantum Mechanical interpretations of near and far infrared spectra of diatomic molecules, Rotation, vibration and rotation-vibration spectra of diatomic molecules (as examples of rigid and non-rigid rotators, harmonic and anharmonic oscillators and symmetric top), vibrational isotope effect, intensities in rotational spectra, thermal distribution of quantum states, effect of nuclear spin on intensities of rotational spectrum.

The hydrogen molecule, Heitler-London treatment, hydrogen ion molecule, bonding and antibonding electrons, Fluorescence and Raman Spectra.

ELECTIVES (any one group)

ELECTRONICS

Paper- V: 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 ands low frequency compensations.

Operational Amplifier: Ideal Opamp. Emitter coupled differential amplifier, CMRR. Effect of constant current source IC opamp (emitter follower, level translation and output device). Off-set error voltage and current and their 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 up to second order, amplitude and time scaling, Active filter, Butter-worth filter, active, resonant, band pass filter.

Nonlinear 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 up to combination logic, Flip Flop: D, SR, JK Master slave, JK Register and counters. Shift Register, ripple counter, up down asynchronous and synchronous counters, ring counter and sequence generators.

Paper- VI: 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, Q of a cavity generator, 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 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.

Microwaves Measurements: Power, frequency, VSWR, Impedance, dielectric permittivity, Network Analyzer and Scattering coefficients.

LASER AND SPECTROSCOPY

Paper- V: LASER SPECTROSCOPY

Detection of light: Thermal and Direct photo detectors, Optical multichannel analyser, Basic elements of laser, threshold- condition, optical resonator.

Laser as spectroscopic light sources, Advantage of lasers in spectroscopy, Fixed-frequency and Tunable lasers, Frequency spectrum of multimode lasers, mode selection, tunable coherent light sources. Tunable Infrared lasers (semiconductor diode laser only), Dye lasers, Excimer lasers, High sensitivity detection methods, excitation and photoacoustic spectroscopy, Laser induced fluorescence spectra.

Stimulated Raman scattering, Coherent Antistoke Raman Spectroscopy, Laser photochemistry, laser isotope separation, Laser monitoring of Atmosphere, Medical Applications of Laser Spectroscopy.

Paper- VI: ELECTRONIC SPECTRA OF DIATOMIC MOLECULE

Quantum Mechanical interpretation of Vibrational and Rotational structure of Electronic band, Frank Condon Principle, Classification of Molecular States, Multiplet Structure, Coupling and uncoupling phenomena, Selection Rules for Electronic Transition, Building up principles and electronic configuration, Basic concept of continuous and diffuse spectra, Determination of heats of dissociation.

MATERIAL SCIENCE

Paper V: MATERIAL SCIENCE- I

Elementary idea of 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. Classification of Materials and their characterization techniques: X-ray Diffraction (XRD), X-ray photoelectron spectroscopy (XPS), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), UV/Vis and FTIR spectroscopy, Thermal Conductivity Measurement Techniques, Ultrasonic Spectroscopy.

Paper VI: MATERIAL SCIENCE- II

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.

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.

M.Sc. FINAL- IV SEMESTER

Paper- I: CLASSICAL ELECTRODYNAMICS

Radiation from a moving charge: Solution of Inhomogeneous wave equation, invariant Green's function, Lienard Weichert Potentials and fields for a moving point charge, Larmor's Formula and its Relativistic Generalization. Angular Distribution of Radiations emitted by an accelerated charge. Thompson Scattering, Simplified discussion of Bremsstrahlung and Cerenkov radiation. Field of a radiation from a localized oscillating source in Far zone. Electric dipole field and radiation.

Radiation Reaction and Self Force: Radiation reaction force from conservation of energy. Electromagnetic mass. Abraham-Lorentz Evaluation of self force. Integro-Differential equation of motion, radiation reaction and line width level-shift, scattering and absorption of radiation by an Oscillator.

Paper- II: SOLID STATE PHYSICS-II

Electron band theory: Bloch theorem, one-electron band theories, Plane wave like and localized wave functions. Nearly free electron approximation. Linear Combination of Atomic Orbitals (LCAO) method, Tight binding approximation, Elementary discussion of Orthogonalized Plane wave (OPW), Augmented Plane Wave (APW) and Pseudopotential methods. Elementary ideas about the experimental study of energy levels.

Semiconductors: Extrinsic semiconductors, variation of Fermi energy. Concept of Degeneracy, many valley semiconductors.

Fermi Surface: Harrison construction of Fermi surface for free electrons, Investigation of Fermi Surface by using cyclotron resonance and de Hass-van Alphen effect experiments.

Superconductivity: Experimental situation, Persistent currents, Meissner effect, isotope effect, Type II superconductors, electronic specific heat, London's equations, coherence length. Simple ideas about screened Coulombic interaction and attractive electron-phonon interaction. Cooper pairs, elementary ideas of BCS theory, ground state energy. Approximate estimate of transition temperature, superconducting energy gap, measurement of energy gap by various methods using infrared absorption, Microwave, Ultrasonics, Giaeuer Tunneling. Josephson effect, SQUIDS and high T_C super conductors.

Paper-III: NUCLEAR AND PARTICLE PHYSICS-II

Nuclear Models: Single particle model of the nucleus, Shell model, Magic numbers, Magnetic moments and Schmidt lines, Collective model (qualitative discussion).

Nuclear Reactions: Scattering and absorption cross sections, Partial wave analysis, Compound nucleus, Level density, Reaction channels, Briet Wigner formula, Principle of detailed balance and reciprocity theorem, Direct reaction, Kinematics of nuclear reactions.

Nuclear Decay: Alpha decay, Gieger-Nuttal law, Gammow theory. Beta decay, Neutrino parity violation, selection rules, Fermi theory, Fermi Curie plots, Comparative half life decay, Gamma multiple radiation, selection rules, photo-disintegration of deuterons, nuclear isomerism.

Particle Physics: Types of interaction between elementary particles and general classification. Invariance and conservation laws, associated production and strange particles, quark model-SU(2)-SU(3) multiplets, Gell-Mann-Okubo mass formula for Octet and decuplet.

Paper-IV: DATA ACQUISITION SYSTEM

Conversion of analog data in to digital data, sampling theorem, sample and hold circuit, A/D converter and D/A converter (ladder/weighted resistor), digital filter (Tapped delay line filter, finite duration impulse response digital filter), Box Car Averaging.

Interface System: Details of IEEE 488 and RS 232, details of bus management lines, handshaking, use of modem in RS 232.

8085 microprocessor: Register, instruction set related to MOV, MV 1 and I/O commands, Addressing I/O devices (memory mapped and I/O Mapped I/O, USART 8251).

ELECTIVES (any one group as in third semester)

ELECTRONICS

Paper-V: 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-VI: PHYSICS OF SEMICONDUCTOR DEVICES

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

p-n junction diode: Junction and diffusion capacitance, diode equation, breakdowns, temperature dependence of voltage and current, Varacter diode and parametric conversion and amplification. Tunnel diode, V- characteristics, tunnel diode as an amplifier and as an oscillator. Gunn diode, modes of operation, power and frequency performance. Impact: Static and dynamic characteristics, small 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 frequencies devices, geometry and performance.

LASER AND SPECTROSCOPY

Paper-V: ADVANCED ATOMIC SPECTROSCOPY

Lamb shift in hydrogen spectrum, Rydberg atoms and Rydberg states, Transition probability, Interpretation of the spectra of two electron systems, Representation of state for coupling schemes, Selection rules, Complex spectra and their interpretation, nitrogen, oxygen and manganese as examples, Alteration of multiplicities, Inversion of states. The atom in a force field. Zeeman and Paschen-Back effect for two valence electron system.

Electron and nuclear magnetic moment, resonance phenomenon, magnetic resonance, quantum mechanical treatment of ESR, NMR, magnetic

hyperfine structure, fine structure in ESR, System suitable for ESR and NMR studies, g-value and effect of anisotropy, relaxation effect, Line shape and line width, Chemical shifts and ENDOR.

Paper-VI: IR AND RAMAN SPECTRA OF POLYATOMIC MOLECULES

Group Theory: Symmetry elements and symmetry operations, point groups, Classification of molecules into Point Groups.

Vibrational motion, motion in Cartesian coordinates, Normal coordinates and normal modes of vibration, quantized vibrational motion, vibrational energy, symmetry coordinates and their application to study molecular vibration, determination of the symmetries of normal modes of vibration, determination of the symmetries of normal modes of vibration of N_2O and CO_2 molecules. Functional Group analysis.

Polyatomic molecules as a rigid rotator and symmetric top, Pure rotational structure in the Raman and Far Infrared spectra of Linear molecule, Alteration of intensity, Inversion of Ammonia molecule.

Rotation vibration spectra of linear molecule, Selection rules and Transition of Rigid Rotator-Harmonic Oscillator model, Parallel and Perpendicular bands in linear molecules.

MATERIAL SCIENCE

Paper V: MATERIAL SCIENCE- 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. Ideas about lattice ontribution to thermal conductivity.

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

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 VI: MATERIAL SCIENCE- 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 Hamiltonian 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.

List of Experiments: Semester-III & IV

Electronics

1. (a)Mode Analysis of klystron
   (b)Characterization of Directional coupler and Magic T and calibration of Attenuator
2. (a) Measurement of VSWR
   (b)Measurement of complex dielectric constant of material at microwave frequency
   (c) Verification of square law of crystal detecror
3. Dielectric constant of a dispersing medium at RF frequencies.
4. ESR
5. Steady state and transient response of wide band amplifier.
6. Characterization of OpAm: CMRR, Open loop gain bias voltage and bias currents, slew Rate.
7. Characterization of Summer, Integrator and Differentiatior
8. Analog computation
9. Active filters
10. log and Antilog Amplifiers and multiplication
11. A/D and D/A converter
12. Microprocessor
13. Video Amplifier
14. IC familiarization
15. Microstrip line
16. Logicom

Laser and Spectroscopy

1. Study of Zeeman Effect
2. Study of L.I.F spectra
3. Study of Laser excited spectra
4. Laser induced fluorescence study of chlorophyll.
5. Raman spectra of organic liquids
6. Recording and analyzing: (a) Rotational spectrum, (b) Determination of Rotational constants
7. Detection of unknown elements by recording emission spectra.
8. Intensity measurement of spectral lines.
9. (a) Determination of Heat of Dissociation of diatomic halogen molecules.

(b)Study of Predissocation in S2 emission and absorption spectra.

10. Study of Spark Arc Spectra
11. Study of opto galvanic effect in Neon discharge.

Materials Science

1. Hall Effect.
2. Measurement of Energy Gap in Semiconductor Four Probe Method.
3. Hysteresis Characterization of Different Samples.
4. Lattice Dynamics of monoatomic and diatomic lattices.
5. Measurement of Curie Temperature.
6. ESR Experiment.
7. Measurement of tunneling current through a metal-insulator junction.
8. Thermoluminescence of F-centres.
9. Measurement of energy gap, refractive index and absorption coefficient of semiconductor by using optical method.