

## B.Sc Part – III

### 1. PHYSICS

#### Scheme

Paper I.	Exam: 3 hours duration	Min Pass marks: 12	Max Marks : 33
Paper II.	Exam: 3 hours duration	Min Pass marks: 12	Max Marks : 33
Paper III.	Exam: 3 hours duration	Min Pass marks: 12	Max Marks : 34
Practical	Exam: 4 hours duration	Min Pass marks: 18	Max Marks : 50

#### Paper I: Quantum Mechanics and Spectroscopy

Work Load: Two hours lecture per week.

Examination Duration : 3 hrs.

Scheme of Examination: Five question shall be set and all are compulsory. First question shall contain 12 short answer type questions (3 questions from each unit) of one mark each with answer not exceeding 50 words. Candidates have to attempt any nine questions out of these 12 questions. Remaining four questions will be of 6 marks each and will be set with one question from each unit. Second to fifth questions will have 100% internal choice.

#### Unit – 1 : Evolution of quantum physics

1. Difficulties of classical mechanics to explain: the black – body emission spectrum, specific heat of solids. Plank quanta concept and radiation law, Photo electric effect and Einsten's explanations, Compton effect, De-Broglie hypothesis, diffraction and interference experiments of particle ( Davission – Germer experiment).
2. Uncertainly principle: position and momentum, angle and angular momentum, energy and time. Application of uncertainly principle: (i) Ground state energy of hydrogen atom, (ii) ground state of simple harmonic oscillator, (iii) Natural width of spectral lines, (iv) Non-existence of electron in nucleus.
3. Operators: linear operators, product of two operators, commuting and non- commuting operators, simultaneous eigen function and eigen values, orthogonal wave functions, Hermitian operators, their eigen values, Hermitian adjoint operators, eigenvalues and eigenfunctions; expectation values of operators: position, momentum, energy; Ehrenfest theorem and complementarity, Concept of group and phase velocity, wave packet, Gaussian wave packet, bra-ket notation.

## Unit – II : Schrödinger wave equation and its solutions

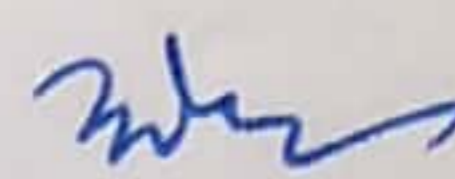
1. Schrödinger wave equation: general equation of wave propagation, propagation of matter waves, time dependent and time-independent Schrödinger equation, wave function representation( $\Psi$ ), physical meaning of  $\Psi$ , properties and conditions on  $\Psi$ , postulates of wave/Quantum mechanics, operators, observable and measurements; probability current density.
2. Time independent Schrödinger equation, stationary state solution, one dimensional problem; particle in one dimensional box, eigenfunctions and eigenvalues, discrete energy levels, generalization into three dimension and degeneracy of energy levels, concept of a potential well and barrier, step potential, penetration through rectangular barrier, reflection and transmission coefficients, barriers with special shapes (graphical representation), quantum mechanical tunneling(alpha decay).

## Unit – III : Schrodinger equation solution in special cases

1. Symmetric square well potential, reflection and transmission coefficients, resonant scattering; Bound state problems: particle in one dimensional infinite potential well and finite depth potential well, energy eigenvalues and eigenfunctions, transcendental equation and its solution; Simple harmonic oscillator, Schrödinger equation for simple harmonic oscillator and its solution, eigenfunction, eigenvalues, zero point energy, quantum and classical probability density, parity, symmetric and antisymmetric wave functions with graphical representation.
2. Schrödinger equation in spherical coordinates, Schrödinger equation for one electron atom in spherical coordinates, separation into radial and angular variables, solution of radial equation and angular equation, qualitative discussion of spherical harmonics, series solution and energy eigenvalues, stationary state wave function. Wave-functions of H-atom for ground and first excited states, average radius of H-atom, Bohr correspondence principle, orbital angular momentum and its quantization, commutation relation, eigenvalues and eigenfunctions.

## Unit – IV: H-atom, Atomic and Molecular spectroscopy

1. Energy level derivation for H-atom, quantum features of hydrogen spectra and hydrogen like spectra, Stern-Gerlach experiment, electron spin, spin magnetic moments, spin-orbit coupling, qualitative explanation of fine structure, Franck-Hertz experiment, Zeeman effect, normal Zeeman splitting, Qualitative understanding about Stark effect.
2. Absorption and emission spectroscopy, its block diagram, brief explanation about function of each elements and it's limitations; single beam spectrophotometer.
3. Molecular spectroscopy: concept of rigid rotator, rotational energy levels, rotational spectra, selection rules, intensity of spectral lines, isotopic effect; Vibrational energy levels, vibrational



spectra, selection rules, isotopic effect, effect of anharmonicity in vibrational spectra, vibrational-rotational spectra of CO and HCl molecules.

#### Reference books

1. David J. Griffiths, Introduction to Quantum Mechanics, 2<sup>nd</sup> edition.
2. R. Shankar, Principles of Quantum Mechanics, 2<sup>nd</sup> edition.
3. Arthur Beiser, Perspective of modern Physics, 6<sup>th</sup> edition.
4. A. K Ghatak and S Lokanathan, Quantum Mechanics: Theory and application.
5. HS Mani, GK Mehta, Introduction to modern Physics.
6. C.N. Banwell and E.M. McCash, Fundamental of Molecular Spectroscopy, 4<sup>th</sup> edition.
7. H.E. White, Introduction to atomic physics.

### Paper – II : Nuclear and Particle Physics

**Work Load** : Two hours lecture per week

Examination Duration : Three hours

Scheme of Examination: Five questions shall be set and all are compulsory. First question shall contain 12 short answer type questions (3 questions from each unit) of one mark each with answer not exceeding 50 words. Candidates have to attempt any nine questions out of these 12 questions. Remaining four questions will be of 6 marks each and will be set with one question from each unit. Second to fifth questions will have 100% internal choice.

### UNIT – 1

Properties of Nucleus : Discovery of Nucleus, Rutherford Scattering, Constituents of the Nucleus; Mass, Charge, Size, Nuclear Density, Charge Distribution, Hofstadter's experiment.

Nuclear Angular momentum, Nuclear Magnetic, Dipole Moment, Electric Quadrupole Moment, Spin, Isospin, Wave Mechanical Properties: Parity and Statistics, Classification of Nuclei, Mass Defect and Binding Energy, Packing Fraction, Mass Spectrograph.

**Nuclear Forces:** Properties of Nuclear Forces, Yukawa Meson Theory, Nuclear Potential.

**Nuclear Models:** Segre Chart, Liquid Drop Model, Semi Empirical Mass Formula, Condition of Stability, Fermi Gas model, Evidence for Nuclear Shell Structure, Nuclear Magic Numbers and Basic Assumptions of the Shell Model.

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## UNIT - 2

**Radioactive Decays:** Alpha Decay-Basics of  $\alpha$ -Decay Processes, Theory of  $\beta$  Emission Spectrum, Gammow Factor, Geiger Nuttal Law, Range of Alpha Particles.

Beta Decay Energy Kinematics for  $\beta$ -Decay Spectrum, Positron Emission, Electron Capture, Pauli's Neutrino Hypothesis.

Gamma Decay - Gamma Ray Emission and Kinematics, Internal Conversion Applications of Radioactivity.

**Nuclear Fission and Fusion:** Nuclear Fission, Spontaneous Fission and Potential Barrier, its Explanation by Liquid Drop Model, Chain reaction, Controlled chain reaction, Four Factor Formula, Nuclear Reactors, Classification of Nuclear Reactor, Uncontrolled Chain Reaction, Nuclear Fusion, Energy released in Nuclear Fusion, Fusion in stars.

**Nuclear Reactions:** Types of Reactions, Conservation Laws, Kinematics of Reactions, Q-Value, Threshold Energy, Reaction Rate, Reaction Cross-Section.

## UNIT - 3

**Interaction of Nuclear Radiations with Matter:** Energy Loss by Heavy Charged Particles in Matter, Interaction of Electrons with Matter, Range of Charged Particle, Bremsstrahlung, Cherenkov Radiation, Gamma Ray Interaction with Matter.

**Radiation Detectors:** Gas filled detector, Avalanche, Geiger Discharge, Ionization Chamber, Proportional Counter, Geiger Muller Counter, Current mode and Pulse Mode Operation of Detector.

**Particle Accelerators:** Ion source, Van-de-Graff Accelerator (Tandem Accelerator), Linear Accelerator, Cyclotron, Synchrocyclotron, Betatron, Proton Synchrotron.

## UNIT - 4

**Elementary Particles:** Necessity of high energy to discover elementary constituents, historical introduction to discovery of elementary particles (electron, positron, neutrinos, strange mesons, charm quark, intermediate vector bosons, bottom quark, top quark and Higgs boson) Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.), elementary particles included in the standard model.

**Fundamental Interactions :** Four types of fundamental forces, Symmetries and Conservation Laws, Discrete symmetries C,P, and T invariance, Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction, CP violation.

**Quark Model :** Flavor symmetries, Gellmann-Nishijima formula, the eightfold way, Quark model, Octet Diagram for Mesons and Baryons, Concept of Quark model, the November Revolution, Baryon Decuplet, Color Quantum Number and Gluons.

### Suggested Books :

1. Nuclear and Particle Physics, W.E. Burcham and M Jobes, Addison Wesley Longman Inc.
2. Nuclear and Particle Physics, Brian R Martin, John Wisley & Sons.
3. Introduction to Nuclear and Particle Physics, Das and Ferbal, World Scientific.
4. Elements of Nuclear Physics, Walter E. Meyerhof, McGraw-Hill Book Company.
5. Introductory Nuclear Physics, Kenneth S. Krane, John Wiley & Sons.
6. Introduction to Elementary Particles, David J. Griffiths, John Wiley & Sons.
7. Radiation Detection and Measurement, G.F. Knoll (John Wiley & Sons).
8. Introduction to Nuclear and Particle Physics, V.K. Mittal, R.C. Verma, S. C. Gupta, PHI.
9. Concepts of Modern Physics, A. Beiser, McGraw-Hill Book Company.

## Paper – III ( Solid State Physics)

**Work Load :** Two hours lecture per week

Examination Duration: Three hours

Scheme of Examination: Five question shall be set and all are compulsory. First question shall contain 12 short answer type questions (3 question from each unit) of one mark each with answer not exceeding 50 words. Candidates have to attempt any **ten questions** out of these **12 questions**. Remaining four questions will be of 6 marks each and will be set with one question from each unit. Second to fifth questions will have 100% internal choice.

### UNIT – I

#### **Bonding in Solids and Crystal Structure:**

Force between atoms, Ionic bonds, Covalent and metallic bonds, Vander Waal's and Hydrogen bonding. Periodicity in lattices, Basis, lattice point and space lattice. Translation vectors, Unit and primitive cell, Crystal systems, Packing fractions for Simple Cubic (SC), Body Centred Cubic (BCC), Face Centred Cubic (FCC) and Hexagonal lattice structures, Bravais space lattices.

#### **Crystallography and Diffraction:**

Direction, planes and Miller indices in a crystal lattice, Reciprocal lattice and its significance, Conversion of SC and FCC Structures in reciprocal lattice frame, Concept of crystalline, polycrystalline and amorphous materials, X-rays: FWHM, Sherrer formula and Lattice Constants (for simple cubic structure), Electron and Neutron diffraction (qualitative).

### UNIT – II

#### **Band theory of Solids:**

Formation of bands, Periodic potential and Bloch Theorem, Number of states in the bands, Kronig Penny model, Brillouin zones, Crystal momentum and physical origin of effective mass, Negative Effective Mass and Holes, Energy dispersion relations: weak and tight binding.

#### **Semiconductors:**

Energy band Structure in Insulators, Conductors, Semi-conductors, Concept of Direct and Indirect band gap in semi-conductors, Generation and recombination of charge carriers, Mobility of current carriers, Hall Effect in semi-conductors: Hall coefficient, Mobility, Charge carrier concentration, Conductivity and Hall angle.

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### UNIT – III

#### Thermal properties of Materials:

Elastic waves, Phonon, Phonon dispersion relations in monoatomic and diatomic linear lattice. Lattice heat capacity, Classical theory of specific heat, Dulong-Petit's law, Einstein and Debye's theory of specific heat of solids and limitations of these models, concept of Thermoelectric Power.

#### Electrical Properties of Materials:

Drude-Lorentz theory, Sommerfeld's Model, Thermal conductivity, Electrical conductivity, Wiedemann-Franz relation, Thermionic Emission, Escape of electrons from metals, Hall Effect in Metals, Density of states.

### UNIT – IV

#### Magnetic Properties of Materials:

Classification of Magnetic Materials, Origin of Atomic Magnetism, Classical Langevin Theory of dia – and Paramagnetic Domains, Quantum theory of Paramagnetism. Curie's Law, Weiss's Theory of Ferromagnetism. Concept of Domain Wall, Magnetostriction, Heisenberg's Exchange Interaction, Relation between Exchange Integral and Weiss Constant.

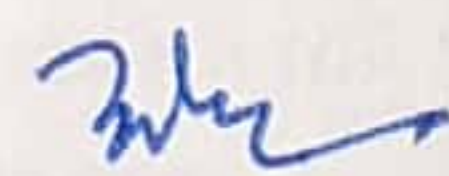
#### Superconductivity:

Experimental features of superconductivity: Critical Temperature, Critical magnetic field, Meissner effect. Type I and Type II Superconductors, London's Equation and Penetration Depth. Isotope effect, idea of BCS theory (No derivation); Cooper Pair and Coherence length, Josephson Effect (No derivation)

#### Reference Books

1. Introduction to Solid State Physics ---- Charles Kittel (Wiley Publication)
2. Elementary Solid state Physics ----- M. Ali Omar (Pearson Education)
3. Elements of X-ray diffraction ---- B.D. Cullity (Prentice Hall)



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## Practical Work

Teaching: 4 hrs/per week

Examination Duration: 4 hrs

Minimum Pass Marks: 18

Max. Pass Marks: 50

Note: Total number of Experiments to be performed by the students during the session should be 16 selecting any 8 from each section.

### Section – A

- 1.(A) Determination of Planck's constant with the help of a photo cell.
- 2.(A) To determine Planck's constant using solar cell.
- 3.(A) To determine the value of Stefan's constant.
- 4.(A) To Study the change in resistivity of any semiconductor with temperature by four probe method.
- 5.(A) Study of absorption spectrum of Iodine.
- 6.(A) Study the characteristics of G.M. counter and hence verification of inverse square law/ for radioactive radiations.
- 7.(A) Determination of end point energy of  $\beta$  particles by using Geiger Muller counter and study of their absorption by aluminium.
- 8.(A) Determination of magnetic susceptibility of ferromagnetic / paramagnetic material by using Quinck's method and determination of ionic molecular susceptibility of ions and magnetic moment in terms of Bohr Magneton.
- 9.(A) Determination of modulus of rigidity of given material in the form of torsional oscillator using resonance method and study of dependence of modulus of rigidity on temperature.
- 10.(A) To study the polarization by reflection due to glass plate by using Nicol prism and photo cell and prove the Brewster and Mallus laws.
- 11.(A) To find  $e/m$  of electron by Helical method.
- 12.(A) Measurement of magnetic field of an electro-magnet using a ballistic galvanometer, search coil and standard inductor. Study the variation of magnetic field of an electromagnet with the current.
- 13.(A) To determine the frequency of unknown Ac Source by Lissajous figures.
- 14.(A) To study frequency response of R-C coupled double stage amplifier.\*
- 15.(A) To determine the charge of an electron by Millikan's oil drop experiment.

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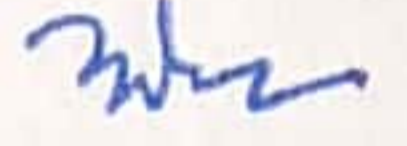
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### Section – B

- 1.(B) To study R-C Transmission line at 50 Hz.
- 2.(B) To study L-C Transmission line.
- 3.(B) Object : Study of resonance in an LCR circuit (using air core inductance and damping by metal plate). (i) at fixed frequency by varying C, and (ii) – by varying frequency.
- 4.(B) To study the characteristics of given junction and zener diodes.
- 5.(B) Study of (i) Recovery time of a junction diode and a point contact diode. (ii) Recovery time as a function of frequency of operation and switching current.
- 6.(B) To design a zener regulated power supply and study the regulation with various loads.
- 7.(B) (i) To Study and draw the characteristics curve of a given field effect transistor (FET).  
(ii) To design a FET amplifier and to study its gain frequency response.
- 8.(B) To study the gain frequency response of a transistor amplifier with (a) Resistive load, (b) Inductive load, (c) transformer load, and (d) to find its input and output impedance.
- 9.(B) To design and study an R-C phase shift oscillator.
- 10.(B) Study of voltage multiplier circuit and conversion of alternating current into direct current with it.
- 11.(B) Study of OR, AND and NOT logic gates by applying different components and hence their comparison with the gates formed with integrated circuits (IC's).
- 12.(B) (i) To Study the operational amplifier in (a) Inverting mode, and (b) Non inverting mode, (ii) Application of operational amplifier as (a) Adder amplifier, and (b) a Buffer amplifier for unit gain voltage measurement.



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