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

Scheme of Examination: First question will be of nine marks comprising of six short answer type parts each with answer not exceeding half a page. Remaining four questions will be set with one question from each of the unit and will be of six marks each. Second to fifth question will have two parts namely (A) and (B) each carrying three marks. Part (A) of second to fifth question shall be compulsory and Part (B) of these questions will have internal choice.

Unit – I : 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 Einstein's explanations. Compton effect, De-Broglie hypothesis, diffraction and interference experiments of particle (Davisson-Germer experiment).

2. Uncertainty principle: position and momentum, angle and angular momentum, energy and time. Application of uncertainty principle: (i) Ground state energy of hydrogen atom, (ii) ground state energy 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 functions and eigen values, orthogonal wavefunctions, Hermitian operators, their eigenvalues, Hermitian adjoint operators.

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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, wavefunction representation (ψ), physical meaning of ψ, properties and conditions on ψ, postulates of wave 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 : Schrödinger equation solutions 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 wavefunction. 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

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moment. 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, 2nd edition.
2. R. Shankar, Principles of Quantum Mechanics, 2nd edition.
3. Arthur Beiser, Perspective of modern Physics, 6th edition.
4. AK 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, 4th edition.
7. H.E. White, Intoduction to atomic physics,

Paper II: Nuclear and Particle Physics

Work Load: Two hours Lecture per week

Scheme of Examination: First question will be of nine marks comprising of six short answer type parts each with answer not exceeding half a page. Remaining four questions will be set with one question from each of the unit and will be of six marks each. Second to fifth question will have two parts namely (A) and (B) each carrying three marks. Part (A) of second to fifth question shall be compulsory and Part (B) of these questions will have internal choice.

UNIT - I

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

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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.

UNIT - 2

Radioactive Decays: Alpha Decay-Basics of α-Decay Processes, Theory of β-Emission Spectrum, Gammow Factor, Geiger Nuttal Law, Range of Alpha Particles,

Beta Decay-Energy Kinematics for β-Decay, β-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 Radiation 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,

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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. Diescrete 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 Wiley & 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

Workload: Two hours Lecture per week

Scheme of Examination: First question will be of ten marks comprising of five short answer type parts each with answer not exceeding half a page. Remaining four questions will be set with one question from each of the unit and will be of six marks each. Second to fifth question will have two parts namely (A) and (B) each carrying three marks Part (A) of second to fifth question shall be compulsory and Part (B) of these questions will have internal choice.

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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-ray diffraction by solids: Laue and Braggs equation, Study of crystals by 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, Kroning Penny model, Brilliuon zones, Crystal momentum and physical origin of effective mass, Negative Effective Mass and Holes, Energy dispersion relations: weak and tight binding.

Semiconductors:

Energy band Structures in Insulators, Conductors, Semiconductors, Concept of Direct and Indirect band gap in semiconductors. Generation and recombination of charge carriers, Mobility of current carriers, Hall Effect in semiconductors: Hall coefficient, Mobility, Charge carrier concentration, Conductivity and Hall angle.

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.

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Electrical properties of Materials:

[illegible]de-Lorentz theory. Sommerfeld's Model, Thermal conductivity, Electrical conductivity, Wedemann-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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Practicals

Teaching	4 hrs/week	
Max. Marks	Duration	Min. Pass Marks
50	5 hrs.	18

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. Determination of Planck's constant by photo cell (retarding potential method using optical filters, preferably five wave length).
2. Determination of Planck's constant using solar cell.
3. Determination of Stefan's constant (Black body method)
4. Study of the temperature dependence of resistance of a semiconductor (four probe method).
5. Study of Iodine spectrum with the help of grating and spectrometer and ordinary bulb light.
6. Study of characteristics of a GM counter and verification of inverse square law for the same strength of a radioactive source.
7. Study of β-absorption in Al foil using GM Counter.
8. To find the magnetic susceptibility of a paramagnetic solution using Quinck's method. Also find the ionic molecular susceptibility of the ion and magnetic moment of the ion in terms of Bohr magneton.
9. Determination of coefficient of rigidity as a function of temperature using torsional oscillator (resonance method).
10. Study of polarization by reflection from a glass plate with the help of Nichol's prism and photo cell and verification of Brewster law and law of Malus.
11. e/m measurement by helical Method.
12. Measurement of magnetic field using ballistic galvanometers and search coil. Study of variation of magnetic field of an electromagnet with current.
13. Measurement of electric charge by Millikan's oil drop method..

Section–B

1. Study of a R-C transmission line at 50 Hz
2. Study of a L-C transmission line
   (i) at fixed frequency.
   (ii) at variable frequency.
3. Study of resonance in an LCR circuit (using air core inductance and damping by metal plate)

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(i) at fixed frequency by varying C, and
(ii) by varying frequency.

4. Study of the characteristics of junction diode & Zener diode.
5. Study of
   (i) Recovery time of junction diode and point contact diode.
   (ii) Recovery time as a function of frequency of operation and switching current.
6. To design Zener regulated power supply and study the regulation with various loads.
7. To study the characteristics of a field effect transistor (FET) and design/study amplifier of finite gain (10).
8. To study the frequency response of a transistor amplifier and obtain the input and output impendence of the amplifier.
9. To design and study of an R-C phase shift oscillator and measure output impedence (frequency response with change of component of R and C).
10. To study a voltage multiplier circuit to generate high voltage D.C. from A.C.
11. Using discrete components, study OR, AND, NOT logic gates, compare with TTL integrated circuits (I.C.'s).
12. Application of operational amplifier (OP-AMP) as : Minimum two of the following exercises-(a) Buffer (for accurate voltage measurement) (b) inverting amplifier (c) Non inverting amplifier (d) Summing amplifier.

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