KISHKINDA UNIVERSITY

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Recognized by Govt. of Karnataka & UGC New Delhi

Department of Physics

PhD Course Work Syllabus

Course Title:	**Quantum Mechanics**	Credits:	**04**
Course Code:	**24PHY01**	SEE Marks:	**100**
Course Type:	**Self-Study**	Exam Duration:	**03**

Module-1

Basic Principles: Hermitian operators, observables; Eigenfunctions, eigenvalues and orthonormalization of eigenfunctions, completeness. State functions as probability amplitude and the principle of superposition. Momentum, Hamiltonian and energy operators, Schrodinger equation. Probability density and probability current density, expectation value, Ehrenfest's theorem; basic postulates of quantum mechanics. Simple Applications: Eigenvalues and eigenfunctions of free particle, particle in infinite square well and of simple harmonic oscillator by polynomial method, barrier transmission: leakage of free particle through a thick rectangular potential barrier and transmission and reflection coefficients.

Module-2

Hydrogen atom: Particle in spherically symmetric potential, Reduction of two-body problem to a single particle problem. Centre of mass and relative motions; eigenvalues and eigenfunctions. Hydrogen like atom, eigenvalues of energy and eigenfunctions.

Angular momentum: Expression for the three Cartesian components and the square of the angular momentum, their commutation relations, expression for the operators in polar coordinates, eigenvalues and eigenfunctions in terms of polar coordinates; eigenvalues and eigenfunctions of the square and z-component of angular momentum.

Module-3

Time-Independent Perturbation Theory: Eigenvalue of energy and eigenfunction in the first-order approximation (the case of a system with non-degènerate energy levels). Application to anharmonic oscillator and to the ground state of Helium atom.

Module-4

Time-Dependent Perturbation Theory: Concept of the theory, transition from one discrete level to the other, to a continuum states: Fermi's Golden rule. The harmonic perturbation, resonance transitions. Semi-classical theory of Einstein's A & B coefficients. Interaction of radiations with a system of atoms, transition dipole moment, selection rules.

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Module-5

Elastic Scattering: Differential and total cross-section, phase analysis. Significance of the partial waves and phase shifts, S-wave scattering from a square well potential. The Born approximation, derivation of the expression for differential scattering cross-section, condition for validity of the approximation: application to square well potential and screened coulomb potential.

References:

1. Quantum Mechanics – Theory & Applications (5^{th} Ed): A.K. Ghatak & S. Lokanathan, MacMillan India Ltd.
2. A Text of Quantum Mechanics: P.M. Mathews &K. Venkatesan, Tata McGraw-Hill, New Delhi (1982)
3. Quantum Mechanics (2nd ed): G. Aruldhas, Prentice Hall India Pvt.Ltd.,New Delhi (2009)
4. Quantum Physics (3rd ed): S. Gasiorowicz, Wiley India (P) Ltd., New Delhi (2007)
5. Introduction to Quantum Mechanics: L. Pauling & E. Bright Wilson, McGraw-Hill, N.Y. (1935)
6. Quantum Mechanics (3rd ed): L.I. Schiff, McGraw-Hill, N.Y.(1968)
7. Quantum Mechanics: E. Merzbacher, 2nd ed., Wiley, N.Y.(1970)
8. Quantum Mechanics (2nd Ed): V.K. Thankappan, new Age International (P) Ltd. (1993)

Solid State Physics

Course Title:	**Solid State Physics**	Credits:	**04**
Course Code:	**24PHY02**	SEE Marks:	**100**
Course Type:	**Self-Study**	Exam Duration:	**03**

Module: 1

Dielectric & Ferroelectric Properties: Polar and non-polar dielectrics, Dielectric constant, relation between polarization and dielectric constant (Derivation), types of polarization, internal fields in solid (Derivation), Clausius- Mossotti equation (Derivation), Complex dielectric constant, dielectric loss and optical phenomenon, Dielectric losses and relaxation time, Classical theory of electronic polarization and optical absorption. Ferroelectricity, general properties, classification, dipole theory and its drawbacks, thermodynamics of ferroelectric transitions, ferroelectric domains.

Module: 2

Semiconductors: Classification of materials based on band theory of solids, Band gap, holes, Effective Mass, mobility in intrinsic semiconductors, direct and indirect band gap, Fermi level in an intrinsic semiconductor (Derivation), Expression for concentration of electrons in conduction band & concentration of holes in valance band, Law of mass action, Electrical

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conductivity of a semiconductor (Derivation), Hall effect, Expression for Hall coefficient and its application. Photodiode and Power responsivity, Solar cell, LED, Tunnel diode.

Module: 3

Crystal structure: Unit cell, primitive cell & lattice parameters, Bravais lattice & Crystal systems, Miller indices, Coordination number and Atomic packing factor for SC, BCC & FCC structures, Interplanar spacing in terms of miller indices, NaCl, CsCl, structures. Closely packed structures, point and space groups. Reciprocal Lattice, relation between direct & reciprocal lattice, Bragg's law, Laue method, Ewald's construction.

Module: 4

Magnetic materials: Introduction, susceptibility & permeability, classification & properties of magnetic materials; Dia, Para and Ferro; Magnetic hysteresis, Ferromagnetic domains, Soft & Hard magnetic materials. Atomic origin of magnetism, Langevin diamagnetism, Para magnetism - Classical and quantum theories; Curie-Weiss law, Molecular field theory, Antiferromagnetism and ferrimagnetism, Principle and Theory of Paramagnetic resonance and Nuclear magnetic resonance.

Module: 5

Conductivity in metals: Free Electron Theory of Metals, Qualitative discussion of Free-Electron Model of metals; Electrical conductivity, Electrical Resistivity versus temperature, Heat capacity of conduction electrons, Fermi surface, Electrical conductivity and effects of Fermi surface, Thermal conductivity in metals, Bloch theorem, Kronig-Penny model, Brillouin zone and construction in square lattice, Energy versus wave-vector relationship - different representations / zone schemes, Number of wavefunctions in a band, Velocity and effective mass of electron.

References:

1. Principle of the theory of solids: J.M. Ziman (Cambridge University Press)
2. Introduction to Solid State Physics: C. Kittel (Wiley Eastern)
3. Solid State Physics: A.J. Dekkar (Prentice Hall Inc)
4. The physical principles of solids: A.H. Morish
5. Semiconductor Physics: P.S. Kireev (MIR Publishers)
6. Solid State Science: K. Seeger (Springer Verlag)
7. Introduction to Magnetic Materials, B. D. Cullity, C. D. Graham, (Wiley) 2nd ed.
8. Elementary Solid State Physics. M. Ali Omar, Pearson Edu. Inc, 2016

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Materials Characterization Techniques

Course Title:	**Materials Characterization Techniques**	Credits:	**04**
Course Code:	**24PHY03**	SEE Marks:	**100**
Course Type:	**Self-Study**	Exam Duration:	**03**

Module-1

Fundamentals of Analytical Instruments: Types of chemical analysis, Elements of analytical instrument, Sensors and transducers, Classification of transducers, Performance characteristics of Transducers, Smart sensors, Signal processing in analytical instruments, read out systems, types of instrumental methods, classification of analytical instruments. Application of statistical methods, Signal to noise ratio. Sensitivity, selectivity, specificity, resolution, range, limit of detection, linearity.

Module-2

Infrared and Raman Spectroscopy: Infrared Absorption Spectroscopy: Range of Infrared Radiation, Modes of vibrations, Basic components of IR spectrophotometers (Radiation sources, monochromators, slits, mirrors, sample cells, sampling substance, and detectors) Types of IR spectrophotometers: Optical null method and Ratio recording method; sample handling techniques, Fourier transform infrared spectrometer. (Ref: 1,2) Raman Spectroscopy: Raman effect: Principle, characteristic properties of Raman lines, Raman spectrometer (Sources, sample chamber, Detectors), PC based Raman spectrometer, FT Raman spectrometer, Applications, comparison between Raman and Infrared spectroscopy.

Module-3

Absorption and Emission Spectroscopy: UV-Visible Absorption spectroscopy: Beer-Lambert's law, construction and working of single and double beam absorption spectrometers, applications. Atomic absorption spectroscopy: Principle, Instrumentation (Radiation sources, Burners and flames, Atomization, Optical system, Electronic system, Sampling system), Applications. Atomic emission spectrophotometer: Instrumentation, Plasma excitation sources (Direct coupled plasma, inductively coupled plasma, microwave induced plasma). Photoluminescence: Principles of fluorescence and Phosphorescence, Jablonski diagram, Instrumentation of spectro-fluorimeter and phosphorescence spectrometer. (Ref: 1-6)

Module-4

X-ray, Electron and Ion spectroscopy: X-ray Diffraction: Bragg's law, X-ray diffraction methods and associated instrumentation, Applications. Electron spectroscopy: Auger Electron Spectroscopy (AES), Scanning Electron Microscopy (SEM); Transmission Electron Microscopy (TEM). Scanning Tunneling Electron Microscopy (STEM), Atomic Force Microscopy (AFM). Ion Spectroscopy: Secondary Ion Mass Spectroscopy (SIMS), Ion Scattering Spectroscopy.

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Module-5

Electric, Magnetic, Nuclear and Thermal techniques: Instrumentation of impedance analyzer. Impedance, dielectric constant and dielectric loss measurements using impedance analyzers. Vibrating-sample magnetometer (VSM), Nuclear Magnetic Resonance spectrometer (NMR), Electron Spin Resonance (ESR). Nuclear techniques: Instrumentation of alpha spectrometer with single and multichannel analyzer, Gamma ray spectrometer – NaI (Tl) scintillation detector. Thermo-analytical instruments: Thermogravimetric analysis (TGA), Differential thermal analysis, Differential scanning calorimetry (DSC). (Ref: 1-4)

References

1. Handbook of Analytical Instruments, R.S. Khandpur, 3rd Edition, Tata McGraw-Hill, (2015).
2. Instruments Methods of Chemical Analysis, Chatwal and Anand, Himalaya Publishing House (2019).
3. Instrumental Method of Analysis, Willard, Merritt, Dean and Settle, CBS Publishers and Distributors, Delhi (1986).
4. Principles of Instrumental Analysis, 7th Edition, D. A. Skoog, F. J. Holler, S. R. Crouch, Cengage India Private Limited, (2020).
5. Methods of Experimental Physics, Dudley Williams, Academic press, New York, (1976).
6. Experimental Spectroscopy, Sawyer, Prentice-Hall publisher, (1946).

Conducting Polymers & Composites

Course Title:	**Conducting Polymers & Composites**	Credits:	**04**
Course Code:	**24PHY04**	SEE Marks:	**100**
Course Type:	**Self-Study**	Exam Duration:	**03**

Module-1

Elements of polymer science: Monomers- Polymers- classification of polymers, synthesis of polymers- chain growth polymerization, step growth polymerization, electrochemical polymerization, Metathesis polymerization [Ring opening metathesis polymer (ROMP)]. Average molecular weight- weight number & viscosity, size of polymer molecule. Microstructure of polymers- chemical, geometric, random, alternating and block polymers. Phase transition- polymer melting and glass transition, stereo isomerism, degree of crystallinity.

Module-2

Conducting polymers: Synthesis and properties of conducting polymers- polyacetylene, poly p-phenylene, polyheterocyclic and polyaromatic conducting polymers like polythiophene, polypyrene, polyaniline, polypyrrole, poly phenylene vinylene, polypyridine, methods to enhance the processability of conducting polymers.

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Module-3

Conductivity in conducting polymers: Valance band theory- basic concepts of band model, band model of conductor, semiconductor and insulator. Carrier mobility, intrachain conductivity, interchain conductivity. Concept of doping- Charge carriers: polarons, bipolarons and solitons. Types of dopants, oxidative dopants and reductive dopants, mechanism of doping, p-type doping and n-type doping, inorganic and organic dopants.

Module-4

Dielectric properties of conducting polymers: effect of doping on the dielectric properties of conducting polymers, Dielectric properties of conducting polymers in the high and very high frequency fields (AC fields), ultra-high frequency field (Microwave field). Dielectric constant, dielectric loss and absorption property of conducting polymers in the AC and microwave fields.

Module-5

Composite materials: Introduction & Classification of composite materials, polymer composites – nano, micro and macro scales. Reinforcements – short fibre, long fibre and particulate fillers. Matrices – thermoplastics, thermosets and rubbers. Nano and micro composites. Short and long fibre composites, treatment of reinforcements, polymer-filler interactions, use of coupling and bonding agents.

References

1. Hand book of conducting polymers, T.A. Skotheim, R.L. Elsenbaumer, J.R. Reynolds, 2ed. Marcel Dekker, New york, vol.1-2., (1998).
2. Organic conductive molecules and polymers, H.S. Nalwa, John wiley and sons; vol. 2, England (1977).
3. Conjugated polymers, J. L. Bredas, R. Silbey, Kluwer, Dordrecht, (1991).
4. Encyclopaedia of Polymer science and Engineering, second edition, Vol.5, Mark Bikales over Berger Menges John Wiley and Sons Inc., (1986).
5. Electroactive polymers, M.E.O. Lyons, Ed; Plenum Press; New York, PP 1-65, (1994).
6. Conducting Polymers and Plastics, J. Margolis, Chapman and Hal, London 1993. - 28 - POL 3206.

Nanoscience and Nanotechnology

Course Title:	**Nanoscience and Nanotechnology**	Credits:	**04**
Course Code:	**24PHY05**	SEE Marks:	**100**
Course Type:	**Self-Study**	Exam Duration:	**03**

Module-1 Fundamentals of Nanoscience and Nanotechnology

Introduction to nanoscale science and nanotechnology, quantum confinement effect, Properties of nanomaterials: Electronic, magnetic, and optical, Types of nanomaterials: Organic, inorganic and hybrid.

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Module-2 Synthesis and Fabrication Techniques
Top-down and bottom-up approaches, Physical, Chemical and biological synthesis of nanomaterials, Chemical vapor deposition (CVD), physical vapor deposition (PVD), Co-precipitation, hydrothermal, microwave techniques, Colloidal synthesis of nanoparticles and nanowires, Surface functionalization and modification, green synthesis by using plant and organism extractions.

Module-3 Characterization Techniques for Nanomaterials
Structural characterization techniques: X-Ray Photoelectron Spectroscopy (XPS), X-Ray topography, Energy Dispersive X-Ray Analysis (EDAX), Principles and applications of X-Ray Diffraction, Surface characterization Techniques: Scanning electron microscopy (SEM), Transmission electron microscopy, Basic principles and applications of scanning probe techniques (SPM), Atomic force microscopy, and scanning tunneling microscopy.

Module-4 Optical, Electrical and Magnetic Characterization, Spectroscopic techniques
UV-Visible spectroscopy, Fourier Transform infrared (FT-IR) Spectroscopy, Raman Spectroscopy techniques: Photo luminescence Spectroscopy.
Electrical characterization Techniques: Hall Measurement, capacitance, and voltage measurements, I-V analysis, electrochemical measurements (cyclic voltammetry), Magnetic & Dielectric Characterization: SQUID, Dielectric measurements, impedance and ferroelectric measurements,

Module-5 Applications of Nanomaterials
Nanomaterials for Energy and Environment: Nanomaterials for solar cells, photocatalysis fuel cells, energy storage, gas sensor and humidity sensor and environmental applications. Nanomaterials in Nanobiotechnology and Nanomedicine: Nanoparticles for drug delivery and diagnostics, Pharmaceutical applications, Nano-bio interfaces and biosensor, imaging techniques in nanomedicine.

References:

1. Nano: The Essentials: Understanding Nanoscience and Nanotechnology by T. Pradeep, Tata McGraw-Hill 2008
2. Nanotechnology: Principles and Practices by Sulabha K. Kulkarni. Springer, 2014
3. Nanomaterials by A.K. Bandhyopadhyay, New Age 2008
4. Principles of Nanotechnology by Phanikumar, Scitech Publications, Chennai. 2010
5. Nanoscale Science and Technology by Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons, Ltd., UK, 2005

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