

**Part - A**  
**Research Methodology**

**Introduction:**

Definition and Objectives of Research, Research Design, Need for Research Design, Components of Research Design, Various Stages of Scientific Research, Selection of Research Problem and Hypothesis. Basic Principles of Experimental Design, Important of Experimental Designs.

**Literature Survey:**

Primary and Secondary Sources-Reviews, Monographs, Patents, Current Literature Methods, Abstract of Research Papers, Bibliography Databases, Web as source of information, Use of Search Engines, Application of Microsoft Package. Use of Library and Internet.

**Data Collection, analysis, Reporting and Thesis Writing:**

Collection of Data, Observation Method, Experimental Measurements, Analysis of Data, Error Analysis, Types of errors, Correlation and Regression analysis, Plotting Pictures and Graphs, Structure and Components of Scientific papers, Technical Reports, Illustrations and Tables. Preparation of Final Manuscript/Thesis, Publishing Research Finding in Good Academic Journals, Proof Reading/Correction of Research Manuscript, Style Manuals, Bibliography Reference and Footnotes etc., Layout of Thesis, Issues Related to Copyright-Reproduction of Published Materials – Royalty, IPR, patenting, TRIPS, Plagiarism, Structure of Viva, Defending Viva.

**Characterisation Techniques:**

XRD, UV-VIS-NIR- SEM, TEM, CVD, DC/RF Sputtering, Absorption Spectroscopy-Photoluminescence and Raman spectroscopy, Emission Spectroscopy- FT-IR and NMR Spectroscopy and TG-DTA/BET analysis, Temporal measurement of Pulse duration – nanosecond, picosecond and femtosecond pulses. Impedance spectroscopy measurements, Electrical transport measurements: 2-probe and 4-probe techniques, I-V curve analysis, Lab-View interface techniques.

**Lab safety:**

Lab safety procedures/precautionary steps–MSDS – Storage and disposal of chemicals/ solvents – environmental issues.

**Reference books:**

1. Fundamental of Research Methodology and Statistics by Y. K. Singh
2. Research Methodology by R. Panneer selvam published by PHI LEARNING PVT LTD.
3. How to write and Publish” by Robert A. Day and Barbara Gastel, (Cambridge University Press).
4. “How to Research” by Loraine Blaxter, Christina Hughes and Malcum Tight, (Viva Books).
5. A Students's Guide to Methodology” by Peter Clough and Cathy Nutbrown, (Sage Publications).
6. Kothari C.R., Research Methodology – Methods and Techniques, New Age International (P) Ltd, New Delhi, 2003.
7. University of New South Wales, “How to write a Ph.D. Thesis” Sydney, Australia, Science @ Unsw.

## Syllabus for PhD - Materials Science

**1. Structure and bonding in materials:** Atomic structure and electronic configuration, concept of atomic orbital quantization and quantum numbers: principal, orbital and spin magnetic moment, metallic, ionic, covalent non-covalent and mixed bonding; structure of materials: fundamentals of crystallography, crystal systems, Bravais lattice, unit cell, packing fraction, crystallographic planes and directions; structures of metals, ceramics, polymers, amorphous materials and glasses.

**2. Defects in crystalline materials:** Point defects: vacancies, interstitials, Frenkel and Schottky defects with examples, line defects: dislocations; grain boundaries., solid solution in metals and ceramics

### **3: Thermodynamics**

Concept of extensive and intensive properties, system, surrounding, state and path function, isothermal, adiabatic and reversible thermodynamic processes, laws of thermodynamics, Carnot cycle, Clausius inequality, concept of heat, enthalpy, entropy and free energy.

### **4: Properties and Applications of Materials**

Mechanical properties of metals, ceramics, polymers and composites at room temperature; stress strain response (elastic, anelastic and plastic deformation), strength, hardness, toughness- its applications.

**Electronic properties:** Basics in semiconductors, band gap, Hall effect, P-N junction, transistors dielectric behaviour, piezoelectricity, pyroelectricity and ferro-electricity, examples of insulator, semiconductor, conductor and superconductors.

**Magnetic properties:** Origin of magnetism in materials, Magnetic susceptibility, B-H hysteresis loop: differences for diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic and ferri-magnetic materials, examples for each of the types

**Thermal properties:** Specific heat, heat conduction, thermal conductivity of materials-application.

**Optical properties:** Nature of light, photoelectric effect, wave-particle duality, absorption and transmission of electromagnetic radiation, refractive index, electronic transitions, LASER.

**5. Structure and property measurement techniques:** Basic concepts of X-ray diffraction; spectroscopic techniques such as Ultra-violet - Visible absorption spectroscopy, Atomic absorption spectroscopy, Fourier Transformed Infra-Red spectroscopy, and Raman spectroscopy; optical microscopy, electron microscopy.

**6. Materials synthesis, processing and stability:** Precipitation, Sublimation, Thin film, Crystallisation, Annealing and Sintering. Basic concept of corrosion, classifications, basic electrochemistry, corrosion prevention, thermal degradation.

**7. Nanomaterials and Nanotechnology** – Basic concept of nanomaterials, classifications: bulk, two-dimensional, one-dimensional, and zero dimensional nanomaterials, quantum dots, quantum confinement effect, surface to volume ratio, size dependent effect in optical properties of gold and CdSe, application in Nanotechnology.