

# **MAHATMA GANDHI UNIVERSITY**

## **Ph.D. COURSE WORK SYLLABUS**

### **COURSE I- RESEARCH METHODOLOGY**

#### **Unit 1 – SCIENCE AND RESEARCH:**

Definition – History – Evolution of Scientific Inquiry – Verification versus falsification – Objectivity: Facts, theory and concepts – Philosophy of Science and Technology, Epistemology of sciences – Construction of scientific facts.

#### **Unit 2 - INTRODUCTION TO RESEARCH METHODOLOGY**

- Meaning and importance of Research – Types of Research – Selection and formulation of Research Problem
- Research Design – Need – Features – Inductive, Deductive and Development of models
- Developing a Research Plan – Exploration, Description, Diagnosis, Experimentation, Determining Experimental and Sample Designs.
- Analysis of Literature Review – Primary and Secondary Sources, Web sources –critical Literature Review
- Hypothesis – Different Types – Significance – Development of Working Hypothesis
- Research Methods: Scientific method vs Arbitrary Method, Logical Scientific Methods: Deductive, Inductive, Deductive-Inductive, pattern of Deductive – Inductive logical process – Different types of inductive logical methods.

#### **Unit 3 - DATA COLLECTION AND ANALYSIS**

- Sources of Data – Primary, Secondary and Tertiary – Types of Data – Categorical, nominal & Ordinal.
- Methods of Collecting Data : Observation, field investigations, Direct studies – Reports, Records or Experimental observations.
- Sampling methods – Data Processing and Analysis strategies- Graphical representation – Descriptive Analysis – Inferential Analysis- Correlation analysis

– Least square method - Data Analysis using statistical package –  
Hypothesis – testing – Generalization and Interpretation – Modeling.

#### **Unit 4 – SCIENTIFIC WRITING**

- Structure and components of Scientific Reports – types of Report – Technical Reports and Thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports - Illustrations and tables – Bibliography, Referencing and foot notes – Oral presentation – Planning – Preparation and practice – Making presentation – Use of visual aids – Importance of Effective Communication.
- Conventions and strategies of Authentication – Citation Style - sheet
- Preparing Research papers for journals, Seminars and Conferences – Design of paper using TEMPLATE, Calculations of Impact factor of a journal, citation Index, ISBN & ISSN.
- Preparation of Project Proposal - Title, Abstract, Introduction – Rationale, Objectives, Methodology – Time frame and work plan – Budget and Justification  
- References

#### **Unit 5 – APPLICATION OF RESULTS AND ETHICS**

Environmental Impacts - Ethical Issues – Ethical Committees – Commercialization – copy right

– royalty – Intellectual Property rights and patent law – Track Related aspects of intellectual property Rights – Reproduction of published material – Plagiarism – Citation and Acknowledgement – Reproducibility and accountability.

#### **Unit 6 – APPLICATION OF COMPUTER IN RESEARCH**

- MS office and its application in Research – MS Word, MS Power point and MS Excel
- Basic principles of Statistical Computation using SPSS
- Use of Internet in Research – Websites, search Engines, E-journal and E-Library – INFLIBNET.

#### **References: Science**

1. Garg.B.L., Karadia, R., Agarwal,F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R.(2008). Research Methodology: Methods and Techniques. Second Edition. New Age International Publishers, New Delhi.

3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270 p.
5. Day RA (1992) How to write and publish a scientific paper. Cambridge University press. London
6. Hempel,C. Philosophy of Natural science Englewood Cliffs, N.J: Prentice Hall, 1966.
7. Burt, E.A. The Metaphysical Foundations of Modern Science. London, 2003.
8. Latour, B. & Woolgar. 3. Laboratory Life. The construction of scientific facts. 2<sup>nd</sup> Edition. Princeton: Princeton University Press.1986
9. Gupta S.P. (2008). Statistical Methods. 37<sup>th</sup> ed. (Rev)Sultan Chand and Sons. New Delhi. 1470 p.
10. Sundar Sarukkai (2008)Indian Philosophy and Philosophy of Science, Motilal Banarsidass Publishers Pvt.Ltd. New Delhi.
11. Kozak A, Kozak R.A., Staudhammer C.L., and Watts S.B. (2008). Introductory probability and Statistics; Applications for forestry and Natural sciences.CAB International, UK.408p.
12. Downine N.M Basic Statistical Methods. New York: Harper and Health Row Publishers,.....
13. Frank, Harry. Statistics. Concepts and Applications. Cambridge. Althoen, Steven Cambridge University.
14. Leon & Leon (2202). Internet for everyone, Vikas Publishing House.
15. Wadehra, B.L.2000. Law relating to patents, trade marks, copyright designs and geographical indications. Universal Law Publishing.
16. Chandera A. and Sexena T.P.(2000) Style Manual, New Delhi, Metropolitan Book Comp. Ltd.
17. SPSS – Operating Manual and handbook – Latest version
18. Sinha p.K.(1992). Computer Fundamentals, BPB Publications, New Delhi.

## **COURSE II – INSTRUMENTAL METHODS OF ANALYSIS IN CHEMISTRY**

### **Unit I: SPECTROSCOPIC METHODS**

General principles, Instrumentation and applications of the following spectroscopic techniques.

Infrared Spectroscopy (IR), Roman Spectroscopy, nuclear Magnetic Spectroscopy (NMR), **Electron Spin Resonance (ESR)**, Mossbauer Spectroscopy, **Nuclear Quadrapole Resonance (NQR) Spectroscopy**, Fluorescence Spectroscopy, Atomic Absorption Spectroscopy (AAS), Atomic Emission spectroscopy (AES), Inductively Coupled Plasma Atomic Emission spectroscopy, UV/Visible Spectroscopy and Mass Spectroscopy.

### **Unit 2 : SURFACE ANALYSIS**

Principles, instrumentation and applications of Auger Electron Spectroscopy, Secondary Ion Mass spectroscopy (SIMS), X-ray Photoelectron Spectroscopy (XPS)

### **Unit 3: MICROSCOPIC TECHNIQUES**

Working Principle, instrumentation and applications of Atomic Force Microscopy (AFM), **Optical microscopy, Polarizing Optical Microscopy, Interference Microscopy, Fluorescence Microscopy**, Scanning Probe Microscopy (SPM), Scanning Tunneling Microscopy (STM), Transmission Electron Microscopy (TEM), Techniques of preparing samples for microscopy, Fourier Transformation in Microscopy.

### **Unit 4 : THERMAL ANALYSIS:**

Principles, instrumentation and applications of Differential Scanning calorimetry (DSC), Thermo Mechanical Analysis (TMA), Thermo gravimetric Analysis (TGA), Dynamic Mechanical Spectroscopy (DMS), Differential Thermal Analysis (DTA), Dielectric Thermal Analysis (DETA), **Thermal Conductivity, Thermal Diffusivity, Effusivity**

### **Unit 5: CHROMATOGRAPHIC TECHNIQUES**

Principles, Instrumentation (basic components) and applications of gas chromatography, High Performance Liquid Chromatography (HPLC), **Ion Exchange Chromatography: Size Exclusion Chromatography**, Thin Layer Chromatography, Inverse Gas Chromatography.

### **Unit 6: SCATTERING TECHNIQUES;**

Principles, Instrumentation (basic components) and application of X ray Diffraction (XRD) technique SAXS and WAXD, **Dynamic and Static Light Scattering, SALS**, Turbidimetry, Nephelometry and small angle neutron scattering techniques.

### **Unit 7: MOLECULAR WEIGHT DETERMINATION**

Principles, Instrumentation (basic components) and application of Osmometric Techniques – Vapour Pressure Techniques (VPO), membrane Osmometry (MO), Differential Refractometry and Light Scattering technique

## **Unit 8: DIELECTRIC SPECTROSCOPY/IMPEDANCE SPECTROSCOPY**

Principles, Instrumentation (basic components) and application Surface Resistivity, Dielectric Spectroscopy/Impedance Spectroscopy, Volume Resistivity, Dielectric Loss, Arc Resistivity spectroscopy/Impedance Spectroscopy, Volume Resistivity, Dielectric Loss, Arc Resistivity

## **Unit 9: MECHANICAL AND VISCOELASTIC CHARACTERIZATION**

Properties of materials in tension, compression, bending, absorption, flexural modes, Static mechanical properties, Dynamic properties, creep, stress relaxation and dynamic mechanical properties.

## **Unit 10: FLOW/RHEOLOGICAL CHARACTERIZATION**

Viscosity determination, capillary rheometer, rotational rheometer, different types of viscometers

## **Unit 11: OPTICAL CHARACTERIZATION**

Haze, Gloss, Transparency, Scattering, color, luster, streak, index of refraction, dispersion, luminescence, fluorescence.

## **Reference Books**

1. Fundamentals of analytical chemistry, Douglas A.Skoog, Donald M.West, F.James Holler, Stanley R.Crouch: Thomson Brooks/Cole (8<sup>th</sup> Edition).
2. Spectrometric identification of Organic compounds, Silverstein, Bassler and Morrill; John Wiley & sons, New York, 1981.
3. Instrumental methods of analysis, Willard, Merritt and Dean
4. Vogel's Text book of quantitative inorganic analysis, J Basset, R.C.Denny; Langman group, Lardan, G.H.Jeffery and J.Mendham (5<sup>th</sup> Edition)
5. Spectroscopy, G.R.Chatwal and S.K.Anand; Himatay publishing aHouse 2002.
6. Spectroscopic identification of organic compounds, R.M.Silverstein and Webster.
7. NMR in chemistry – A multinuclear introduction, William Kemp.
8. Instrumentation to modern chromatography. L.R.Snyder and J.J.Kirkland: John Wiley and Sons, Inc (II Edition)
9. Introduction to High Performance Liquid Chromatography, Hamilton, R.J; Chapman AND Hall, 1978
10. Fundamentals of molecular spectroscopy, N.Banwell; Tata McGraw Hill 1994 (4<sup>th</sup> Ed.)
11. Applications of absorption spectroscopy of organic compounds. J.R.Dyer; Prentice Hall of India.
12. Spectroscopy of Organic Compounds. P.S.Kalsi; New Age International, New Delhi
13. Spectroscopic Methods in Organic Chemistry, D.H.Williams, I.Fleming: Tata McGraw Hill, New Delhi 2005 (5<sup>th</sup> Ed.)
14. Instrumental Methods of Chemical Analysis, Chatwal, G.R. and Anand S.K; Himalaya Publishing House, 2007 (5<sup>th</sup> Edition.)

## **COURSE III-NANOTECHNOLOGY IN PHOTOCATALYSIS (special paper)**

### **Unit 1: INTRODUCTION TO NANOMATERIALS**

Introduction, classification of nanomaterials - zero, one, two and three-dimensional structures, mechanical, structural, optical, electrical, and magnetic properties of nanomaterials, applications of nanomaterials.

### **Unit 2: SYNTHESIS OF NANOMATERIALS BY PHYSICAL AND CHEMICAL METHODS**

Chemical precipitation and co-precipitation methods, sol-gel synthesis, solvothermal synthesis, microwave synthesis, sonochemical synthesis and synthesis in super critical fluids. Inert gas condensation, arc discharge, plasma arc technique, RF plasma, MW plasma, ion sputtering, laser ablation, laser pyrolysis, chemical vapour deposition method and electro deposition.

### **Unit 3: CRYSTAL STUDY AND SURFACE ANALYSIS OF NANOMATERIALS**

X-ray diffraction, small angle X-ray scattering, scanning electron microscopy (SEM), scanning probe microscopy (SPM), TEM and EDAX analysis, scanning tunnelling microscopy (STM), atomic force microscopy (AFM).

### **Unit 4: SPECTROSCOPIC AND THERMAL CHARACTERISATION OF NANOMATERIALS**

Application of spectroscopy in nanotechnology, operational principle and application of UV-VIS spectroscopy and Raman spectroscopy, principle and application of DTA, TGA, DSC.

### **Unit 5. NANOTECHNOLOGY IN PHOTOCATALYSIS**

Photocatalysis, mechanism of photocatalysis, advantages of semiconductor photocatalysts, nano photocatalysts (g-C<sub>3</sub>N<sub>4</sub>, ZnO, GO), application of nano photocatalysts in pollution remediation and in fuel production.

### **Reference books**

1. Nanochemistry: A Chemical Approach to Nanomaterials by G.A. Ozin, A.C. Aresnault, L. Cadematriri, RSC Publishing 2005.
2. Nanotechnology: Principles and Practices by Sulabha K Kulkarni, Capital Publishing Company, 2007
3. Chemistry of Nanomaterials: Synthesis, Properties and Applications by C. N. R. Rao, A. Muller, A. K. Cheetham, Wiley Publications, 2004.
4. Essentials of Nanotechnology by Jeremy Ramsden, Ventus Publishing Aps, 2004.
5. An Introduction to Nanoscience and Nanotechnology by Alain Nouailhat, Wiley Publications, 2008.
6. Nano: The Essentials by T. Pradeep, Tata McGraw Hill, 2007.
7. Nanomaterials Chemistry: Recent Developments and New Directions by C. N. R. Rao, A. Muller, A. K. Cheetham, Wiley Publications, 2007.
8. Nanophotocatalysis and Environmental Applications by Inamuddin, M. I. Ahamed, A. M. Asiri, Springer, 2019

## **COURSE III- PHOTOCATALYTIC APPLICATIONS OF NANOMATERIALS (special paper)**

### **Unit 1: INTRODUCTION TO NANOMATERIALS**

Introduction, classification of nanomaterials- zero, one, two and three-dimensional structures, mechanical, structural, optical, electrical and magnetic properties of nanomaterials, applications of nanomaterials.

### **Unit 2: FABRICATION OF NANOMATERIALS BY CHEMICAL METHODS**

Chemical precipitation and co-precipitation methods, sol-gel synthesis, solvothermal synthesis, hydrothermal synthesis, microwave synthesis, sonochemical synthesis, and synthesis in super critical fluids.

### **Unit 3: FABRICATION OF NANOMATERIALS BY PHYSICAL METHODS**

Inert gas condensation, arc discharge, plasma arc technique, RF plasma, MW plasma, ion sputtering, laser ablation, laser pyrolysis, ball milling, chemical vapour deposition method, and electro deposition.

### **Unit 4: CHARACTERIZATION OF NANOSTRUCTURES**

X-ray diffraction, small angle X-ray scattering, scanning electron microscopy (SEM), scanning probe microscopy (SPM), TEM and EDAX analysis, scanning tunnelling microscopy (STM), atomic force microscopy (AFM), UV-Vis and Raman spectroscopy-principle of operation and application, thermal characterisation of materials using DTA, TGA, DSC (principle and application).

### **Unit 5: NANOTECHNOLOGY IN PHOTOCATALYSIS**

Photocatalysis, mechanism of photocatalysis, semiconductor nanophotocatalysts (TiO<sub>2</sub>, ZnO, GO), advantages of photocatalysis, applications of nano photocatalysts in pollution remediation and in fuel production.

### **Reference books**

1. Nanochemistry: A Chemical Approach to Nanomaterials by G. A. Ozin, A.C. Aresnault, L. Cadematriri, RSC Publishing 2005.
2. Nanotechnology: Principles and Practices by Sulabha K. Kulkarni, Capital Publishing Company, 2007.
3. Chemistry of Nanomaterials: Synthesis, Properties and Applications by C.N.R.Rao, A.Muller, A.K.Cheetham, Wiley Publications, 2004.
4. Essentials of Nanotechnology by Jeremy Ramsden, Ventus Publishing Aps, 2004.
5. An Introduction to Nanoscience and Nanotechnology by Alain Nouailhat, Wiley Publications, 2008.
6. Nano: The Essentials by T.Pradeep, Tata McGraw Hill, 2007.
7. Nanomaterials Chemistry: Recent Developments and New Directions by C.N.R.Rao, A.Muller, A.K.Cheetham, Wiley Publications, 2007.
8. Nanophotocatalysis and Environmental Applications by Inamuddin, M. I. Ahamed, A. M. Asiri, Springer, 2019.

## **COURSE IV-RESEARCH AND PUBLICATION ETHICS**

### **Theory**

#### **RPE 01: PHILOSOPHY AND ETHICS (3hrs)**

1. Introduction to Philosophy: definition, nature and scope, concept, branches
2. Ethics: Definition, moral philosophy, nature of moral judgements and reactions.

#### **RPE 02: SCIENTIFIC CONDUCT (5hrs.)**

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

#### **RPE 03: PUBLICATION ETHICS (7 hrs.)**

1. Publication ethics: definition, introduction and importance
2. Best practices/standards setting initiatives and guidelines: COPE, WAME etc.
3. Conflicts of interest
4. Publication misconduct: Definition, concept, problems that lead to unethical behavior and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

### **Practice**

#### **RPE 04: OPEN ACCESS PUBLISHING (4hrs.)**

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

#### **RPE05: PUBLICATION MISCONDUCT (4 hrs.)**

##### **A. Group Discussions (2 hrs.)**

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

##### **B. Software tools (2 hrs.)**

1. Use of plagiarism software like Turnitin, Urkund and other open source software tools

#### **RPE 06: DATABASES AND RESEARCH METRICS (7 hrs.)**

##### **A. Databases (4hrs.)**

1. Indexing databases
2. Citation databases: Web of Science, Scopus etc.

##### **B. Research Metrics (3hrs.)**

1. Impact factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics

