# Learning Outcomes- based Curriculum Framework and syllabus for PhD (Nanoscience) (2023-2024)

CREDIT STRUCTURE for Ph.D. (Nanoscience)

**School of Nano Sciences [CUG, GANDHINAGAR] (2023-2024)**

| Course Code | Course Title | Credits |
|---|---|---|
| **Semester I (Total Credits -09)** | | |
| **CORE COURSES** | | |
| NSC 604 | Research and Publication Ethics | 02 |
| NSC 615 | Research Methodology and Writing | 03 |
| NSC 620 | Statistics and ICT for Research Purpose | 02 |
| | **OTHER COURSE** | |
| NSC 644 | Seminar-I | 02 |
| **Semester II (Total Credits - 07)** | | |
| **CORE COURSE** | | |
| NSC 662 | Instrumentation | 03 |
| **OPTIONAL COURSES (total 02 credits from any one courses given below)** | | |
| NSC 671 | Applied Nanochemistry | 02 |
| NSC 672 | Bio-Nanotechnology | 02 |
| NSC 673 | Microwave Processing of Materials | 02 |
| NSC 674 | Materials Science and Technology | 02 |
| | **OTHER COURSE** | |
| NSC 691 | Seminar-II | 02 |
| | Total | 16 |

***Program Outcomes:*** *On completion of PhD (Nanoscience) program, the students will be able to*

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| PO1 | Acquire scientific depth and application of nanoscience and nanotechnology in different research areas like energy, electronics, health, agriculture, environment etc. |
| PO2 | Generate innovative ideas and develop practical skills in designing of nanomaterials and fabrication of nano devices. |
| PO3 | Evolve independent critical thinking, analysis and interpretation of data for proper implementation of research outcome |
| PO4 | Nurture skills for working as effective team member and efficient management of time and work. |
| PO5 | Understand the wider impact of their research for societal needs and industrial application. |

**Program Specific Outcomes:** On completion Ph.D. (Nanoscience) program, the students *will be able to*

| | |
|---|---|
| PSO1 | Understand Research and Publication ethics. |
| PSO2 | Develop and apply novel nanomaterials for energy, electronics, and environment applications. |
| PSO3 | Implement statistical and ICT tools for interpretation and presentation of data. |
| PSO4 | Knowledge of advanced characterization tools to conduct quality research on nanostructured materials. |
| PSO5 | Understand the concept and application of nanoscience in the area of agricultural biotechnology and drug delivery. |

# Semester-I

**CORE COURSES**

## NSC 604: Research and Publication Ethics – (2 Credits)

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|---|---|---|
| *Pre-requisites for the Course*: Master's degree in Science | | |
| **Course Objective:** To create awareness about the publication ethics and publication misconducts | | |
| **Course outcome:** On completion of the course, the students will be able to: | | |
| Unit-I | LO1 | Understand the basics of philosophy of science and ethics |
| Unit-II | LO2 | Understand research misconduct and importance of research integrity |
| Unit-IIÌ | LO3 | LO2 Understand research misconduct and importance of research integrity |
| Unit-IV | LO4 | Recognize importance of open access publications and initiatives Enable students to choose right journal for publishing |
| Unit-V | LO5 | Understand publication misconduct and identify predatory publications. Learn to use plagiarism tools for plagiarism free work |
| Unit-VI | LO6 | Understand databases and research metrics (citations, h-index, Impact Factor, etc. |
| **COURSE CONTENT** | | |
| **Unit I**<br>**Philosophy and Ethics**<br>Introduction to philosophy: definition, Nature and scope, concept, branches, Ethics: definition, moral philosophy, nature of moral judgements and reactions | | |
| **Unit II**<br>**Scientific Conduct**<br>Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP), Redundant publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data | | |
| **Unit III Publication Ethics**<br>Definition, introduction and importance, Best practices / standards setting initiatives and guidelines: COPE, WAME, etc., Conflicts of interest, Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types, Violation of publication ethics, authorship and contributorship, identification of publication misconduct, complaints and appeals, predatory publishers and journals | | |
| **Unit IV**<br>**Open Access Publishing**<br>Open access publications and initiatives, SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies, Software tool to identify predatory publications developed by SPPU, Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc | | |
| **Unit V**<br>**Publication Misconduct**<br>Group Discussions: Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad, Software tools, Use of plagiarism software like Turnitin, Urkund and other open source software tools | | |

**Unit VI**

**Databases and Research Metrics**

Citation databases: Web of Science, Scopus, etc. Research Metrics: Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score Metrics: h-index, g index, il0 index, altmetrics

**Text/ References:**


1. Bird, A. (2006). Philosophy of Science. Routledge.
2. MacIntyre, A. (1967). A Short History of Ethics. London.
3. Chaddah, P. (2018). Ethics in competitive research: Do not get scooped; do not get plagiarized.

On Being a Scientist. 'A Guide to Responsible Conduct in Research' (2009) National Academy of Sciences, National Academy of Engineering and Institute of Medicine. 3rd Ed. National Academies Press.

5. What is ethics in research & why is it important. National Institute of Environmental Health Sciences, by Resnik, D. B., 1 —10. Retrieved from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm, 2011.
6. Beall, J. (2012). Beall's list of predatory publishers 2013. Scholarly Open Access. Nature, 489(7415), 179—179. https://doi.org/10. 1038/489179a
7. Muralidhar, K., Ghosh, A., & Singhvi, A. K. (2021). Ethics in science education, research and governance. Indian National Science Academy


## NSC 615: Research methodology and writing (3 Credits)

*Pre-requisites for the Course*: Master's degree in Science

**Course Objective:** To educate students about the research and the process involved on completion of the course, the students will be able to:

**Course outcome:** On completion of the course, the students will be able to:

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| Unit-I | LO1 | Understand the basic idea of research and its different types. |
| Unit-II | LO2 | Understand the research design and its various essential components. |
| Unit-III | LO3 | Understand the basic idea of scientific writing and referencing. |

**COURSE CONTENT**

**Unit I**

**Introduction to research**

Meaning and nature of research, Types of research, Research theories, Scientific and Experimental methods in research, Interdisciplinary and multidisciplinary research, Inductive, deductive, and intuitive sources of knowledge, Qualities of a researcher.

**Unit I**

**The research process**

Research design, Definition, and identification of research problem, Aims and objectives of research, Hypothesis: meaning, types and significance, Survey and review of literature, Methods of data collection, Data processing and analysis, Organization and presentation of data, Validity of data

**Unit-III Research writing**

Writing research report, manuscripts and research proposal, Structure, and content of reports, manuscripts, proposal, styles of referencing and citations, Bibliography, Use of referencing tools: Mendeley, End Note etc., Types of publication

**Text/ References:**


1. Mertler, C. A., & Charles, C. M. (2011). Introduction to Educational Research. 7th ed. Boston: Pearson/Allyn & Bacon.
2. Bryman, A. (2016). Social Research Methods. Oxford university press.
3. Gibaldi, J. (2009). MLA handbook for writers of research papers. New York, NY: Modern Language Association Press.
4. Kothari, C. R. (2004). Research methodology: Methods and techniques. New Delhi: New Age International Ltd.


## NSC 620: Statistics and ICT for Research Purpose – (2 Credits)

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|---|---|---|
| *Pre-requisites for the Course*: Master's degree in Science | | |
| **Course Objective:** To learn statistical methods and ICT skills for research | | |
| **Course outcome:** On completion of the course, the students will be able to: | | |
| Unit-I | LO1 | Understand the various statistics approaches, implement in data analysis, and learn correlation and regression analysis. |
| Unit-II | LO2 | Learn different ICT tools particularly software for presenting data and drawing schemes. |

**COURSE CONTENT**

**Unit I**

**Statistics and data analysis:**

Measurement scales, normal distribution, Correlation and regression analysis: types of scales, normal distribution, Application of normal probability curve, Null hypothesis, and its importance. Methods of correlation and regression analysis. Inferential statistics: Student t-test, Analysis of variance and co-variance. Non-parametric statistics: Chi-square test.

**Unit II**

**ICT for research purpose**

Web based resources, Search engines and techniques, Web as a tool for scientific literature survey, archive browsing, Research purpose software: Origin and MS Excel, Graph plotting and its types, Curve fitting, and data management, ChemDraw: Use of ChemDraw, The Basics, Drawing Resonance Structures, Drawing Reactions, Drawing Schematics

**Text/ References:**


1. Dowdy, S., Wearden, S. and Chilko, D. (2011). Statistics for research (Vol. 512). John Wiley & Sons. Evans, D. (2009). Introduction to computing explorations in language, logic, and machines. University of Virginia. Tanenbaum, A.S. and Wetherall, D.J. (2010). Computer Networks. 5th Ed.,Pearson publications.
2. Computer Networks 5th By Andrew S. Tanenbaum , 2010, Pearson publications


**OTHER COURSE**

## NSC 643 Seminar I – (2 Credits)

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| *Pre-requisites for the Course*: Master's degree in Science and basic knowledge of computer |
| **Course Objective** To train students in reviewing of literature, analyzing data and presentations. |
| **Course outcome**: On completion of the course, the students will be able to understand the literature, analyze data and present effectively. |

# Semester-II

**CORE COURSES**

**NSC 662: Instrumentation – (3 Credits)**

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| ***Pre-requisites for the Course:*** Basic knowledge of Nano Sciences, Nanotechnology, physics and Chemistry | | |
| **Course Objective:** Introduction to advance instrumentation techniques On completion of the course, the students will be able to: | | |
| **Course outcome:** On completion of the course, the students will be able to: | | |
| Unit-I | LO1 | understand the basics of spectroscopic and microscopic techniques |
| Unit-II | LO2 | learn advanced instrumentation techniques and their principles |
| Unit-III | LO2 | learn mechanical and electrical characterization of materials. |
| **COURSE CONTENT** | | |
| **Unit I**<br>Basic concept of Instrumentation Spectroscopy: UV-VIS-NIR, FT-IR, NMR, Fluorescence Spectroscopy, Chromatography: GC, HPLC, GC-MS, HPTLC, PCR, Electrophoresis. Microscopy: Scanning Electron Microscopy, Transmission Electron Microscopy, High Resolution Transmission Electron Microscopy, Field Emission Scanning Electron Microscopy, Atomic Force Microscopy. | | |
| **Unit II**<br>Advance Instrumentation Techniques Principle, Theory, Working and Application: X-Ray Diffraction, X-Ray Reflectivity, Differential thermal and Gravimetric Analysis, Vibrating sample Magnetometer, Brunauer-Emmett Teller surface areas, Zeta sizer. Scanning Tunneling Spectroscopy, Atomic Absorption Spectrophotometer, Photoluminescence Spectroscopy, Electrochemical Impedance. | | |
| **UNIT-III**<br>Mechanical properties: Ultimate Tensile Strength, Micro hardness, nano indentation (elastic and plastic deformation); Electrical measurements: I-V/C-V characteristics, Hall effect, R-T measurements, Dielectric measurements. | | |
| **Text/ References:**<br>1. Cao, G. (2004). Nanostructures & Nanomaterials: Synthesis, Properties & Applications. Imperial College Press.<br>2. Gogotsi, Y. (2006). Nanomaterials – Handbook. CRC Press, Taylor & Francis Group.<br>3. Edelstein, A.S. and Cammarata, R. (2012). . Nanomaterials: Synthesis, Properties and Applications. Taylor and Francis.<br>(4) Dieter, G. E., & Bacon, D. (1976). Mechanical metallurgy (Vol. 3, pp. 43-53). New York: McGraw-hill. | | |

**OPTIONAL COURSES**

NSC 671: Applied Nanochemistry – (2 Credits)

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|---|---|---|
| ***Pre-requisites for the Course***: Basic knowledge of Nano Sciences, Nanotechnology and Chemistry | | |
| **Course Objective:** To study applications of nanostructures such as nanotubes and nanowires, organic polymers nanostructures, dielectric, ferroelectric, multiferric and magnetic properties of nanomaterials and applications of carbon nanomaterials. | | |
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| **Course outcome:** On completion of the course, the students will be able to: | | |
| Unit-I | LO1 | Learn the synthesis of self-assembled nanoparticles and application of Zero and One-dimensional nanoparticles |
| Unit-II | LO2 | Understand the synthesis and applications of nanocomposites |
| **COURSE CONTENT** | | |
| **Unit I**<br>Basic approaches for the synthesis of nanoparticles, surfactants, self-assembly, phase rule in oil and water system, self-assembled mono layers, LB Films. Applications of zero- dimensional Nanoparticles, applications of one-dimensional nanotubes and nanowires, application of nanoporous materials. | | |
| **Unit II**<br>Preparation and characterization of diblock copolymer-based nanocomposites, application of nanopolymers: application of nanocomposites: metal-metal nanocomposites, polymer-metal nanocomposites, ceramic nanocomposites. Application of organic nanoparticles. Applications of nanocomposites in catalysis. | | |
| **Text/ References:**<br>1. Ozin, G. A., & Arsenault, A. (2015). Nanochemistry: a chemical approach to nanomaterials. Royal Society of Chemistry. The Royal Society of Chemistry, Cambridge, 2nd Ed., 2009.<br>2. Cao, G. (2004). Nanostructures & nanomaterials: synthesis, properties & applications. Imperial College Press, London.<br>3. Kelsall, R., Hamley, I. W., & Geoghegan, M. (Eds.). (2005). Nanoscale Science and Technology. John Wiley & Sons.<br>4. Cantor, B. (Ed.). (2004). Novel nanocrystalline alloys and magnetic nanomaterials. CRC Press.<br>5. Mai, Y. W., & Yu, Z. Z. (2006). Polymer nanocomposites. CRC Press, USA. | | |

**NSC 672: Bio-Nanotechnology – (2 Credits)**

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| ***Pre-requisites for the Course:*** Basic knowledge of nanoscience, biology and biotechnology | | |
| **Course Objective:** To get familiar with Bio-Nanotechnology and its application | | |
| **Course outcome:** On completion of the course, the students will be able to: | | |
| Unit-I | LO1 | Understand the basics and application of Bio-Nanotechnology |
| Unit-II | LO2 | Design the targeted drug delivery systems using nanoparticles for different diseases. |
| **COURSE CONTENT** | | |

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| **Unit I**<br>Bio-nanotechnology Concept Structural Principle of Bio-nanotechnology, Function of Biological molecules, Molecular motors, force, elasticity, Biofilm inhibition by nanoparticles, DNA computers andDNA microprocessors, Biotechnology based genetic engineering**.** |
| **Unit II**<br>Nanotechnology in Drug Delivery Nanoparticle in Drug delivery: Types of Nanoparticles/Nano carrier, Different methods for synthesis of polymeric nano-carrier. Targeted drug delivery, Nanoparticle delivery for Cancer and other disease treatment. |
| **Text/ References:**<br>1. Vo-Dinh, T. (2007). Nanotechnology in biology and medicine: methods, devices, and applications.CRC Press.<br>2. Kumar, C.S.S.R. (2006). Nanosystem Characterization Tools in the Life Sciences. IK International Publishing House Pvt. Ltd. |

**NSC 673: Microwave Processing of Materials– (2 Credits)**

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| *Introduction/Pre-requisites for the Course*: Understanding of Master level Physics/Chemistry. | | |
| *Course Objective*: Introduction to Microwave processing of materials | | |
| On completion of the course, the students will be able to: | | |
| Unit-I | LO1 | Understand fundamental dielectric, magnetic, and conduction properties of materials and how these properties influence microwave interactions with a variety of substances. |
| Unit-II | LO2 | Measurement of permittivity and permeability at microwave frequency. Microwave assisted synthesis of materials ranging from insulators to metal nanoparticles. |

| **COURSE CONTENT** |
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| **Unit I**<br>Dielectric, magnetic, and conduction properties of materials, Maxwell's equation, Historical Background and Recent Trends in Microwave Processing, Characteristics of Microwave Processing, Modes of microwave processing, Behaviour of Materials under Microwaves (MW) |
| **Unit II**<br>MW response of a wide range of materials including food products, glasses, metals, semiconductors, polymers, and ceramics; Microwave assisted synthesis of nanomaterials |
| **Reading List**<br>• Griffiths, D. J. Introduction to electrodynamics.<br>• Gupta, M., & Leong, E. W. W. (2008). Microwaves and metals. John Wiley & Sons.<br>• Dekker, A. J. Solid state physics. Prentice-Hall. |

**NSC 674 Materials Science and Technology– (2 Credits)**

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| *Introduction/Pre-requisites for the Course*: Understanding of Master level Physics/Chemistry. | | |
| *Course Objective* This course examines in-depth the fundamental aspects, properties, and applications of materials. The course will bring in the details about materials science, including atomic structure, crystallography, and the structure-property relationship. The atomic structure and chemical bonding of the material will be investigated. The science and technology of thin films will also be covered. | | |
| On completion of the course, the students will be able to: | | |
| Unit-I | LO1 | Students will learn the fundamentals of atomic structure and atomic bonding, which will aid them in comprehending crystal structure, recognizing crystal structure, and calculating planar and linear densities.<br>Students will learn about the various sorts of defects that may be found in materials, as well as how these defects modify the basic characteristics of the material. Finally, how do these imperfections affect the device's properties?<br>Understanding the fundamentals of phase diagrams can assist them in selecting alloys with certain compositions, as well as the function of heat treatment and other factors in delivering the needed qualities. |
| Unit-II | LO2 | Understanding the various synthesis processes used to create nanomaterials as well as the effects of varied shapes and sizes on the performance of electrical devices.<br>Develop competence in material attribute analysis, material selection for specific applications, and material design to achieve the needed performance parameters.<br>Students will gain an understanding of various thin film deposition processes. developing knowledge and skills that will allow students to pursue careers in manufacturing, engineering, research and development, materials science, or other relevant fields. |

**COURSE CONTENT**

**Unit I**

Crystal structure, imperfections in solids and phase diagram

Basics of atomic structure and bonding in materials, Crystal structure, crystallographic directions and planes, planar and linear density calculation, Crystalline & nanocrystalline materials and crystal structure analysis. Solidification, crystalline imperfection and diffusion in solids, introduction to Phase diagram, Gibbs phase rule, binary isomorphs alloy system, the lever rule, Phase diagrams with intermediate phases, ternary phases diagrams.

**Unit II**

Basics of thin films, introduction and challenges of thermal evaporation, spray pyrolysis, spin coating, electrodeposition, and dip coating methods. Basics of Nano Sciences, Bottom-up and Top-Down approaches, introduction to Emerging technology, Challenges in Nanotechnology, Nanocomposite, and nano electronic devices and ceramic materials.

**Reading List**


- Materials Science and Engineering: An Introduction, William D. Callister 6th edition, John Wiley & Sons.

- NANO: The Essentials: Understanding Nanoscience and Nanotechnology, T. Pradeep, McGraw Hill Education; 1st edition.
- Introduction to Nanoelectronics, Valdimir V. Mitin, Cambridge India; South Asian edition

**Reference Books / Reading Material**

1. Materials Science and Engineering by William F. Smith, 3rd Edition, McGraw- Hill,
2. Introduction to Materials Science for Engineers, Shackelford, 7th Edition, Pearson Prentice Hall
3. Nanostructures and Nanomaterials, 2nd edition, Cao, world scientific

**OTHER COURSE**

**NSC 691 Seminar II – (2 Credits)**

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| *Pre-requisites for the Course*: Master's degree in science and basic knowledge of computer |
| Course Objective To train students in reviewing literature, analyzing data and presentations. |
| Course outcome: On completion of the course, the students will be able to understand the literature, analyze data and present effectively. |