M. Tech. in Nano Science & Technology

Semester I

Sl. No.	Course Code	Course	Contact Hours/week		Credits
			L	T/P	
1	NT-601	Introduction to Nano Science & Technology	3	1	4
2	NT-602	Synthesis of Nanomaterials	3	1	4
3	NT-603	Nano materials for Energy and Environmental objectives	3	1	4
4	NT-604	Nanobiotechnology	3	1	4
5	NT 605	Characterization of Nano Materials	3	1	4
6	MM-606	Mathematics for Computational Materials Engineering	3	1	4
7	PGC-601	Research Methodology and IPR	2	0	2
		Total	**20**	**6**	**26**

Semester II

Sl. No.	Course Code	Course	Contact hours/week		Credits
			L	T/P	
1	NT-606	Nanotechnology for Defense and Industrial Applications	3	1	4
2	AP-610	Advanced Sensors	3	1	4
3		Elective – I [From Department of Applied Chemistry/ Phys/ Metallurgy & Materials Engg.]	3	1	4
4		Elective – II [From Department of Applied Chemistry/ Physics/ Metallurgy and Materials Engg.]	3	1	4
5		Elective – III	4	0	4
6		Elective – IV	4	0	4
7	PGC-602	Audit 1 and 2	4	0	2
		Total	**22**	**4**	**26**

04 weeks of industrial practice school during summer vacation for scholarship students (**optional**)

Semester III

Sl. No.	Course Code	Course	Contact Hours /week		Credits
			L	T/P	
1	NT-651	M. Tech. Dissertation Phase I	28		14
		Total	**28**		**14**

Semester IV

Sl. No.	Course Code	Course	Contact Hours /week		Credits
			L	T/P	
1	NT-652	M.Tech. Dissertation Phase II	28		14
		Total	**28**		**14**

❖ **For MM606 & AP610 please refer respective Department syllabus**

List of Electives/ Self Study

Sl. No.	Course Code	Course Name
1	NT-607	Nanotechnology in Devices
2	AC 608	Safety Health and Hazard Management
3	AC 609	NBC Warfare (Concepts & Remediation)
4	MM 610	Nanomaterials and their applications
5	MM 612	Polymer Blends and Nanocomposites
6	ME 636	MEMS - Design, Fabrication, and Characterization
7	AP-644	Nano photonics
8	Electives from other Department, MOOC/NPTEL courses	

Course Code	Course Name	L – T – P	Credits
NT-601	**Introduction to Nano Science & Technology**	3-0-2	**4**

Course Objectives: The main objectives of this course are to:

1. To understand fundamental concepts of nanoscience and technology
2. To gain knowledge on size dependent various physical and chemical properties

UNIT I: Introduction to Nanotechnology, Scientific Revolutions, Nanotechnology and Nanomachines, Chemical bonding & theories (e.g. Valence band & Molecular Orbital), atomic structure- energy – molecular and atomic size and their properties. Forces between atoms and molecules, particles and grain boundaries, surfaces – strong intermolecular forces, Van der Waals and electrostatic forces between surfaces, covalent and coulomb interactions

UNIT II: Solid State Physics (Overview): Amorphous, crystalline, polycrystals, symmetry, Unit Cells, Crystal Structures (Bravais Lattices), Crystallographic Planes, Miller Indices, Electronic Properties, Classification of materials: Metal, Semiconductor, Insulator, Band, structure.

UNIT III: Implications of nano size on physical and chemical properties: Density of States, large surface to volume ratio, surface functionalization, tunability of properties, Physical Chemistry of solid surfaces, Confinement and transport in nanostructure.

UNIT IV: Nanoscale Phenomenon: Nanoparticles, nano-clusters, nanotubes, nanowires and nanodots. Electronic structure: quantum dots, quantum wires and quantum wells, confinement of electrons energy quantization semiconductor nanocrystals, carbon nanotubes, metal nanostructures, nanofluids, nanoink and hybrid nano materials and nano composites.

Course Outcomes On the successful completion of the course, student will be able to:

1. To understand the fundamental concepts of nanoscience
2. To apply the basic concepts of physics, chemistry and biology concepts to understand the advanced concepts of nanoscience
3. To influence of size and morphology and other factors on various properties of materials.
4. To analyze the acquired knowledge and understanding on real time applications of various applications

Reference Books

1. Pradeep, T., Nano: The Essentials, McGraw Hill Publishers, Mumbai, 2007.
2. Charles P. Poole, Jr. Frank J. Owens, Introduction to Nanotech., John Wiley & Sons2003.
3. Vladimir V. Mitin, Viatcheslav A. Kochelap, Viacheslav iatAleksandrovich Kochelap Introduction to Nanoelectronics: Science, Nanotechnology, Cambridge University – 2008
4. Pignataro, B., Tomorrow's Chemistry Today–Concepts in Nano science, Organic Materials, and Environmental Chemistry, Wiley-VCH, Royal chemical society, 2008
5. Howard, H., Into the Nano Era: Moore's Law Beyond Planar Silicon CMOS (Vol. 106),Springer Series in Materials Science, Springer-Verlag Berlin, 2004.

Course Code	Course Name	L – T – P	Credits
NT-602	**Synthesis of Nanomaterials**	3-0-2	**4**

Course Objectives: The main objectives of this course are to: 1.

1. To understand preparation procedures also the various factors that affects the size and morphology of crystallites.
2. To gain knowledge on current status, future trends and scope for research.

UNIT I: Fundamentals of nucleation and growth: Physical Chemistry of solid surfaces, Crystallization, Interactions between particles.

UNIT II: Top down and bottom-up approach of synthesis: Physical and Chemical routes, Physical Route for synthesis of Nanomaterials: Mechanical (high energy ball milling, melt mixing), physical evaporation methods (Plasma method, Pulse Laser method, spray pyrolysis), sputter deposition, Chemical Vapour Deposition, Arc Deposition, Atomic Layer Deposition.

UNIT III: Chemical Routes for Synthesis of Nanomaterials: Chemical precipitation and coprecipitation; Sol-gel synthesis; Microemulsions or reverse micelles; Solvothermal synthesis; Thermolysis routes, Microwave heating synthesis; Sono-chemical synthesis; Photochemical synthesis; Synthesis in supercritical fluids, Langmuir-Blodgett (LB) Method, Biological route of synthesis: using microorganisms, plant extracts, templates, etc.

UNIT IV: Self Assembly Route: Mechanism of Self Assembly, Some Examples of Self Assembly, Self-Assembly of Nanoparticles using Organic Molecules, Assembly in Biological Systems, Self-Assembly in Inorganic Materials, etc.

UNIT V: Large scale production of nanomaterials and examples.

Course Outcomes

1. To understand fundamental concepts in materials preparation with various morphologies
2. To apply the gained subject knowledge towards understanding the mechanisms involved physical, chemical and mechanical routes
3. To evaluate and understand the role of preparation method towards grain with narrow distribution and desired morphology.
4. To analyze acquired knowledge and understanding on effect of grain morphology and its needs for technological advancements

Reference Books

1. Suvardhan Kanchi, Shakeel Ahmed, Green Metal Nanoparticles, John Wiley & Sons 2018.
2. George Kyzas, Athanasios C. Mitropoulos, Novel Nanomaterials, Intechopen Limited- 2018.
3. G. Cao, Nanostruct. & Nanomaterials: Synth, Properties &Appl, ImperialCollege Press, 2004.
4. J.George, Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005.
5. K. Barriham, D.D. Vvedensky, Low dimensional semiconductor structures: fundamental anddevice applications, Cambridge University Press, 2001.
6. S.P. Gaponenko, Optical Prop. of semicond. nanocrystals, Cambridge Uni.Press, 1980.
7. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate(Eds.), Handbook of NanoScience, Engg.and Technology, CRC Press, 2002.

Course Code	Course Name	L – T – P	**Credits**
NT-603	**Nano materials for Energy and Environmental objectives**	3-0-1	**4**

1. To understand fabrication procedures and working principles of devices such as fuel cells, solar cells, hydrogen generation and energy storage.
2. Possible application of nanomaterials in environmental field.
3. To gain knowledge on current status, future trends and scope for research in energy and environment

UNIT I :- INTRODUCTION

Sustainable energy -Materials for energy -Greenhouse effect -CO2emission -Energy demand and challenges.

UNIT II:-RENEWABLE ENERGY TECHNOLOGY

Development and implementation of renewable energy technologies. Nano, micro and meso scale phenomena and devices. Energy conversion, transport and storage. High efficiency Photovoltaic solar cells. High performance thermoelectric systems -Integration and performance of DSSC- Quantum dots based solar cells.

UNIT III:- NANOMATERIALS IN FUEL CELL AND STORAGE TECHNOLOGY

Micro-fuel cell technologies, integration and performance for micro-fuel cell systems -thin film and microfabrication methods -design methodologies -micro-fuel cell power sources -Supercapacitors -Specific energy-charging/discharging -EIS analysis.

UNIT IV:- HYDROGEN STORAGE AND PHOTOCATALYSIS

Hydrogen storage methods -metal hydrides -size effects -hydrogen storage capacity -hydrogen reaction kinetics -carbon-free cycle-gravimetric and volumetric storage capacities -hydriding/dehydriding kinetics -multiple catalytic effects -degradation of the dye -nanomaterials based photocatalyst design -kinetics of degradation.

UNIT.V:- EMERGINGTECHNOLOGIES FOR ENVIRONMENTAL REMEDIATION

Use of nanoparticles for environmental remediation and water treatment-Role of dendrimer-single enzyme-nanoparticle and metalloprotein. Case studies and Regulatory needs.

Course Outcomes

1. To understand fundamental concepts in energy harvesting and storage systems and environmental system
2. To apply the gained subject knowledge on understanding the mechanisms involved in various devices based on nanostructures and environmental system
3. To evaluate and understand the role of nanomaterials effectiveness over the coarse-grained bulk solids, Bioremediation, Removal of bacteria etc.
4. To analyze acquired knowledge and understanding on commercial and technological trends in both energy harvesting and storage devices and environement

Reference Books

1. Shantanu Bhattacharya, Avinash Kumar Agarwal, T. Rajagopalan, Nano-Energetic Materials,Springer Nature Singapore Pte Ltd. 2019.
2. Xiaoru Wang, Xi Chen, Novel Nanomaterials for Biomedical, Environmental & Energy,2018
3. Handbook of fuel cells: Fuel cell tech and applications by Vielstich. Wiley, CRCPress, 2003.
4. Hydrogen from Renewable Energy Sources by D. Infield 2004.
5. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986.

Course Code	Course Name	L – T – P	**Credits**
NT-604	**Nanobiotechnology**	3-0-1	**4**

1. Understanding the basic of Biology and Nano science and differentiate between nanomaterials and bulk materials
2. Evaluate and critically review the theoretical and practical aspects of Nano materials application
3. Comprehending the novel function resulted from the nanoscale structures using scientific and technological principles in Nano biotechnology

UNIT I: Introduction, History & Applications 1) various definitions and Concept of Nano-biotechnology & Historical background. 2) Fundamental sciences and broad areas of Nano biotechnology. 3) Various applications of Nano-biotechnology 4) Cell – Nanostructure interactions

UNIT II: Biological nanoparticles production, surface functionalization- and their applications plantsand microorganism, Proteins, DNA based nanostructure

UNIT III: Devices based on nano biotechnology – and their applications, lab on a chip.

UNIT IV: Applications of Nanotechnology in Drug: Discovery and Delivery, bioinformatics

UNIT V: Nano materials for dental field and other biomedical applications

Course Outcomes

1. Critically assess and outline the nanotechnology for all areas of application
2. Demonstrate the new properties of Nano materials for next generation needs
3. Comprehend the biological response to nanomaterials
4. Understand the concept of drug delivery via nanotechnology
5. Understand the various biomedical applications of nanomaterials

Reference Books

1. Nanobiotechnology: A Multidisciplinary Field of Science, Basma A. Omran, 2020, Springer
2. Nanobiotechnology: Concepts, Applications and Perspectives, Christof M. Niemeyer, Chad A.Mirkin · 2006, Wiley-VCH
3. Microbial Nanobiotechnology: Principles and Applications, Agbaje Lateef, Evariste BoscoGueguim-Kana, Nandita Dasgupta · 2021, Springer.

Course Code	Course Name	L – T – P	Credits
NT-605	**Characterization of Nano Materials**	3-0-1	**4**

1. To understand the basic analytical technical used for characterization of nanomaterials
2. To demonstrate and understand various spectroscopic techniques.
3. To distinguish various compositional and structural characterization techniques.

UNIT I:- DIFFRACTION TECHNIQUES

Concepts of diffraction, scattering and radiation-matter interactions, X-ray diffraction: powder diffraction, phase identification, Scherrer formula, strain and grain size determination

UNIT II: MICROSCOPY AND IMAGING:

Fundamentals of Imaging: magnification, resolution, depth of field and depth of focus, aberration and astigmatism, Optical microscopy, stereology basics and quantitative analysis, Basic principle and components of SEM: imaging modes, image contrast, illustrative applications, Basic principle and components of TEM: Contrast mechanisms, bright field, dark field, TEM application in crystal defect analysis, Electron diffraction in TEM and its applications, AFM

UNIT III: - SPECTROSCOPIC TECHNIQUES:

X ray Photon Spectroscopy, FTIR, Raman spectroscopy, UV-visible, PL

UNIT IV: THERMAL ANALYSIS TECHNIQUES: DSC, DTA, and TGA

UNIT V: OTHER TECHNIQUES: Dyanamic Light Scattering, Nano indentation, VSM, BET, Magnetic

Course Outcomes

1. To understand the processing and advanced microscope techniques.
2. To obtain knowledge on electrical and magnetic characterization techniques. To obtain knowledge on characterization techniques involved in Thermal
3. To understand the basic difference between thermal and non-thermal techniques

Text Books

Reference Books

1. Suvardhan Kanchi, Shakeel Ahmed, Green Metal Nanoparticles, John Wiley & Sons 2018.
2. Challa S.S.R. Kumar, Nanotechnology Characterization Tools for Tissue Engineering,SpringerNature – 2019.
3. Sverre Myhra, John C. Rivière, Characterization of Nanostructures, CRC Press – 2012.
4. Elements of X-ray Diffraction, B. D. Cullity, Prentice Hall, 2001
5. Materials Characterization, ASM Handbook Vol 10.
6. Characterization of Materials, Vol 1, Elton N. Kaufmann
7. Solid State Chemistry and its Applications, Anthony R. West, Wiley.

Course Code	Course Name	L – T – P	Credits
NT-606	**Nanotechnology for Defense and Industrial Applications**	3-0-1	**4**

1. To understand the role of nanomaterials for energy applications
2. To understand the role of nanotechnology in armor protective system
3. To understand the application of nano materials in industry

UNIT I: Introduction to nano-energetic materials; Applications of nano materials in ammunition, energetic materials, Nano-thermites.

UNIT II: Nanotechnology in stealth and armor protective system

UNIT III: Nano materials in thermoelectric and piezoelectric sensing

UNIT IV: Chemical and biological warfare: Nano materials in detection and decontamination ofCW and BW agents

UNIT V: Nano Coating and Nano composites for industrial Application

Course Outcomes

1. To understand various applications of nanomaterials in ammunitions and related energetic applications of nanoparticles.
2. To understand the basic difference between power of nano versed macro particles.
3. To understand how nanoparticles used in detection and decontamination of chemical and biological warefares.
4. Understand the application of nano particles in industries.

Reference Books

1. Nanotechnology for Defence Applications, Narendra Kumar, Ambesh Dixit, Springer, 2019.
2. Nanotechnology for Chemical and Biological Defense, Margaret Kosal · 2009, Springer
3. Nanotechnology in the Defense Industry: Advances, Innovations and Practical Applications,Madhuri Sharon, Angelica S. L. Rodriguez, Chetna Sharon, Wiley, 2019.

Course Code	Course Name	L – T – P	**Credits**
AC-608	**Safety, Health & Hazard Management**	3-0-1	**4**

Course Objectives:

1. undeerstand the principles of Standards and regulations of hazards management and peculiarities of their implementation.
2. Know prerequisites of the safety principles in management of modern organizations.
3. Be able to use these principles and methods in analyzing and solving problems of organization

UNIT I: CHEMICAL SAFETY: Standards and regulations of chemical safety in Industries or Laboratories, Storage of hazardous chemicals, Compatibility and classification codes, Chemical risk analysis and management, Fire triangle and Handling of Toxic, Industrial Gases

UNIT II: **HAZARD MANAGEMENT**: HAZOP and HAZAN techniques, Hazard in manufacture, Hazard prevention measures, Disposal of hazardous materials

UNIT III: WARFARE: Classifications of explosives based on hazards, Nuclear, biological and chemical warfare safety.

UNIT IV HEALTH: Assessment of human factors, Health & Environment safety, Nano materials safety (Toxicology study) TUTORIALS/ PRACTICALS/ SEMINARS: Handling & demonstration of air-sensitive, pyrophoric and toxic chemicals Monitoring of effluents through Gas Chromatography/Ion Chromatography

UNIT V: PERSONAL PROTECTION

UNIT VI – MSDS for known/ unknown compounds.

Tutorials/ Practical's/ Seminars

1. Handling and demonstration of air sensitive, pyrophoric and toxic chemicals
2. Monitoring of effluents through Gas chromatography / Ion chromatography

Course Outcomes

1. Aware and about the risks and hazards related to occupational health.
2. Get acquainted with the various causes and conducts responsible for unsafe environment.
3. Responsible for minimizing the accidents in work environment. Develop a positive attitude to solve the concerning the principles of sustainable development.
4. Realize the basics of Occupational Health Hazards.
5. Define industrial hygiene and principles.
6. Familiarizes with Process Safety Management (PSM) as per OSHA

Reference Books

1. Safety and accident prevention in chemical operations John Wiley and sons, New York 1982
2. Technical guidance for hazard analysis USEPA, FEMA, USDOT, 1987
3. Nanotechnology Environmental Health and Safety: Risks, Regulation and Management: M.Hull, D. Bowman, Elsevier, 2010
4. Manual on emergency preparedness for chemical hazard, Ministry of Environment and Forest, Govt. of India, New Delhi, 1989.

Course Code	Course Name	L – T – P	Credits
AC-609	**NBC Warfare (Concepts & Remediation)**	3-0-1	**4**

Course Objectives:

1. To understand the principle of NBC
2. Recognize chemical, biological, and radiological (CBR) attack methods.
3. Recognize the need for CBR defense.
4. Identify terms used with CBR

UNIT I: Introduction of nuclear science, types nuclear radiations

UNIT II: NUCLEAR SCIENCE: Structure of nucleus, Mass defect, Binding energy, Nuclear reaction, Fission & Fusion nuclear reactions, Controlled & uncontrolled release of nuclear energy, Concepts of critical mass & critical volume, Principle of operation of fission reactor, detectiontechniques of radiations.

UNIT III: NUCLEAR REACTORS

UNIT IV: NUCLEAR WEAPONS: Principle, Effects: Blast, thermal and radiation, Nuclear bombs (Fission & Fusion Type) Yield of weapon, Protection against nuclear weapons, detection techniques for radiations and disposal of nuclear wastes

UNIT V: CHEMICAL & BIOLOGICAL WEAPONS: Different chemical warfare agents, Their tactical roles / effects, Delivery systems, biological warfare agents & their effects, Protection against biological, chemical warfare agents and their detection, decontamination of CW and BW agents.

UNIT VI : Biological

UNIT VII: Radiological weapon

Course Outcomes

1. To understand the types of nuclear radiations
2. To understand the basic of nuclear science w.r.t fission, fusion, controlled and uncontrolled reactions
3. To understand the concept of nuclear weapons
4. Identify terms used with chemical warfare and biological warfare
5. Understand the difference between chemical and biological weapon with different warfare agents.

Reference Books

1. Principles/Effects & Sensitivity, 1994, C. S. Grace, Brasey series
2. Chemical warfare agents, 1992, S.M.Somai
3. Biological weapons, 1999, Joshua Lederberg