

DEPARTMENT OF APPLIED CHEMISTRY

ABOUT THE DEPARTMENT:

The Department of Applied Chemistry started in 1952 with the aim to impart education and training to DRDO work force in the area of high energy materials and propellants. Over the years Department has moved on to cater to the need of DRDO and civilian students in order to bring the DRDO achievements closer to our society. The Department's aim is to contribute to our understanding of the chemical world through excellence in observational, theoretical and experimental science and to extend quantitative and other appropriate methodologies to address problems in the fields of applied chemical science. In Applied Chemistry, we are endowed with faculties who are dedicated teachers and distinguished researchers that carry out cutting-edge research in all modern areas of Applied Chemistry, as well as in inter-disciplinary areas like nanoscience and technology, high energy materials, polymer science and technology etc.

The first PhD of DIAT (DU) was from the Department of Applied Chemistry and currently it is amongst the Departments guiding very high number of PhD scholars and research publications in DIAT. In addition to PhD, there are numbers of M. Tech. students carrying their PG education. We provide a vibrant and creative learning environment for our students and researchers. We also participate extensively in R&D for various DRDO labs and industries. Dept of Applied chemistry has organized about 20 national, international conference and workshop as well as many customized courses for Ministry of Defence including Tri-services. In recent times, the Department has made significant contributions towards revenue generation through grant-in-projects and customized courses. Currently the dept is conducting three programme viz; MSc in Applied Chemistry, MSc in Food Technology and MTech in Nanoscience and Nanotechnology. The students of the dept after completing the degrees are well placed in industry and also undertake higher studies such as PhD in India and abroad.

M.Tech. in Nano Science & Technology

Description about the programmes:

To impart in-depth and intensive training in theory, testing and practice of chemical science especially in Nanoscience Technology, Chemical Science & Technology & High Energy Materials (HEM), Polymers and Composites to the young scientists of DRDO, other agencies of Ministry of Defence and fresh engineers / postgraduates. The programme covers various disciplines like chemical science & engineering, High Energy materials, polymers and composites, chemistry of nano materials and their applications. The course is suitable for DRDO scientists, service officers and civilians.

Objective

- To provide students with a strong technical education for meeting the modern requirements of technological challenges for chemical industry and academia.
- To train student and provide them ability to gain knowledge in multidisciplinary area
- To impart practical knowledge in the filed of nanoscience, nanotechnology, materials chemistry, physics and electronics.
- To produce market ready technical work-force

Eligibility

BE / B.Tech in any discipline of Engineering, M.Sc. in any discipline of Science.

Qualification: 55% marks or 5.5 CGPA in the qualifying examination as indicated against the disciplines concerned and valid GATE Score Certificate. The qualification should have been obtained from a recognized (by UGC) University / Deemed University / Institution in India.

The candidates who are in the final semester of their degree are eligible to apply; Mark sheet up to the last semester should be enclosed. Provisional certificate in such cases along with Mark sheet of the final semester are required to be submitted before commencement of program.

PROGRAMME OUTCOMES (POs)

- PEO1.** To prepare the graduates for the futuristic cutting-edge technologies at nanoscale
- PEO2.** To develop scientific attitude and skills for applying nanotechnology for advanced application
- PEO3.** To train the graduates to various methods, routes, techniques, instruments for analysis
- PEO4.** To generate technically skilled manpower for innovations in the field of nanotechnology
- PEO5.** To generate human resource for effective scientific contribution for society (both civil and defence sector) through exploiting nanotechnology

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Tech. (Nanotechnology) programme, graduates will be able to

PSO1: Evolving crucial understanding of Nanochemistry, nanophysics and nanoelectronics covering fundamental of Physics, Chemistry of solids, Quantum physics of nanostructures, Nano-electronics and Nano-photonics and nanobiotechnology.

PSO2: Concentrating on specific skills on synthesis of nanomaterials, thin and thick films deposition/fabrication and their characterization

PSO3: Solve research gaps and provide solutions for advancement of science and technology through laboratory practices

PSO4: To create competent scientific work-force through research/product/patent oriented dissertation.

a. Credit Structure

PSC: Program Specific Core **PE:** Professional Elective **PSL:** Program Specific Lab

Semester I				
Sr.No.	Course Type	Course Code	Course	Credits
1	PSC-1	NT-601	Introduction to Nano Science & Technology	3
2	PSC-2	NT-602	Synthesis and Characterization of Nanomaterials	3
3	PSC-3	NT-603	Nanotechnology for Defense and Industrial Applications-I	3
4	PSC-4	NT-604	Nano materials for Energy and Environment	3
5	PE-I		Elective – I from Applied Chemistry, Metallurgical and Materials, Applied Physics, Dept of Electronics Engg & School of Energy & Environment	3
6	PSL	NT612	Laboratory Practical I	3
7	PGC	PGC-601	Research Methodology and IPR	2
			Total	20

Semester II				
Sr.No.	Course Type	Course Code	Course	Credits
1	PSC-5	NT 621	Nanobiotechnology	3
2	PSC-6	NT 622	Nanotechnology for Defense and Industrial Applications-II (NBC Warfare: Concepts & Remediation)	3
3	PE-II	E2	Elective – II from Metallurgical and Materials, Applied Physics, Dept of Electronics Engg & School of Energy & Environment	3
4	PE-III	E3	Elective – III from Metallurgical and Materials, Applied Physics, Dept of Electronics Engg & School of Energy & Environment	3
5	PE-IV	E4	Elective – IV from Metallurgical and Materials, Applied Physics, Dept of Electronics Engg & School of Energy & Environment	3
6	PSL	NT613	Laboratory Practical II	3
7	PGC	PGC-602	Communication Skills & Personality Development	2
			Total	20

Semester III				
Sr.No	Course Code	Course Type	Course	Credits
1	NT-651	Dissertation and Seminar Phase - I	Research Thesis I	20

Semester IV				
Sr.No	Course Code	Course Type	Course	Credits
1	NT-652	Dissertation and Seminar Phase - II	Research Thesis II	20

Course Matrix

Sr No	Program Specific Core	Professional Electives	Program Specific Lab	NPTEL/Swayam Courses
01	NT601: Introduction to Nano Science & Technology	AP-601 (Sem-I) : Fundamental of sensors AND THE COURSES LISTED IN TABLE 1.	NT612 Laboratory Practical I	Biomass Conversion and Biorefinery
02	NT602: Synthesis & Characterization of Nanomaterials	NT-623: (Sem-II) Nano-electronics (IT, AI, ML)	NT613 Laboratory Practical II	Environmental Quality Monitoring & Analysis
03	NT-603: Nanotechnology for Defense and Industrial Applications-I	NT: 624 (Sem-II) Nano-Safety Health and Hazard Management AND THE COURSES LISTED IN TABLE 1.		Physico-chemical processes for wastewater treatment
04	NT604: Nano materials for Energy and Environment	MM610: Nanomaterials and their applications		
05	NT621: Nanobiotechnology	MM612: Polymer Blends and Nanocomposites		
06	NT622: Nanotechnology for Defense and Industrial Applications-II (NBC Warfare: Concepts & Remediation)	ME636: MEMS - Design, Fabrication, and Characterization		
07		AP620: (Sem-II) Nano photonics		
08		AP613: (Sem-I) Semiconductor Photonic Devices		
09		MM602: (Sem-I) Materials Characterization		

Note: Students have to opt for Program-Specific Core courses from the Department only. Professional Electives can be courses from the Department, Other schools/departments, or NPTEL courses. A maximum of 6 credits can be opted by students as a Professional Elective from the list of Online courses on NPTEL/SWAYAM during Sem I and Sem II. It is recommended to take PE-I and PE-II from AC only. The list of Swayam/NPTEL will be reviewed/modified by the school every year.

b. List of NPTEL Approved by BoS for M.Tech NSNT(3 Credit)

Name of Course	Instructor	Institute	Duration	Domain
Biomass Conversion and Biorefinery	Prof. Kaustubha Mohanty	IIT Guwahati	12 Weeks	Energy and Environment
Environmental Quality Monitoring & Analysis	Prof. Ravi Krishna R	IIT Madras	12 Weeks	Energy and Environment
Physico-chemical processes for wastewater treatment	Prof. Vimal Chandra Srivastava	IIT Roorkee	12 Weeks	Energy and Environment

TABLE 1. List of Electives subject for Semester I

Sl. No.	Course Code	Course Name
1	AP 601	Fundamentals of Sensors
2	AP 620	Nanophotonics
3	MM 602	Materials Characterization
4	MM 607	Concepts of Polymer and composite
5	MM611	Nanomaterials and Their Applications
6	MM 614	Biomaterials
7	AP 613	Semiconductor Photonic Devices
8	Electives from other Department, MOOC/NPTEL courses	

TABLE 2. List of Electives subject for Semester II

NT: 623: (Sem-II) : Nano materials for Energy and Environment
NT-624: (Sem-II) Nano-Safety Health and Hazard Management
AP-620: (Sem-II) Nano photonics
TM-610 (Sem-II) : Leadership & Organizational Behaviour :Technology Management Course
TM-602: (Sem-II): AI in Management: Technology Management Course

DETAILED SYLLABUS

Course	Course Name Code	Credits
NT-601	Introduction to Nano Science & Technology	3

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

1. To understand fundamental concepts of chemistry & physics for 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, Chemistry of solid surfaces, Confinement and transport in nanostructure.

UNIT IV: Nanoparticles, nano-clusters, nanotubes, nanowires and nanodots. Quantum dots, quantum wires and quantum wells, Semiconductor and metal nanostructures, carbon nanotubes, nanofluids, nanoink, hybrid nano materials and nano composites.

Reference Books

- Pradeep, T., Nano: The Essentials, McGraw Hill Publishers, Mumbai, 2007.
- Charles P. Poole, Jr. Frank J. Owens, Introduction to Nanotech., John Wiley & Sons 2003.
- Vladimir V. Mitin, Viatcheslav A. Kochelap, Viacheslav Aleksandrovich Kochelap Introduction to Nanoelectronics: Science, Nanotechnology, Cambridge University — 2008
- Pignataro, B., Tomorrow's Chemistry Today—Concepts in Nano science, Organic Materials, and Environmental Chemistry, Wiley-VCH, Royal chemical society, 2008

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 understand various applications

Course Code	Course Name	L	Credits
NT-602	Synthesis & Characterization of Nanomaterials	3	3

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

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.
3. To study various spectroscopic and analytical methods for characterization of nanomaterial

UNIT I: Fundamentals of nucleation and growth: Physical Chemistry of solid surfaces, Crystallization, Interactions between particles. Top down and bottom-up approach of synthesis: Physical and Chemical routes.

UNIT II: Physical Route for synthesis of Nanomaterials: Mechanical (high energy ball milling, physical evaporation methods (Plasma method, Pulse Laser method, spray pyrolysis), sputter deposition, Chemical Vapour Deposition, Arc Deposition etc

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

UNIT IV: 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 V: MICROSCOPY AND IMAGING:

Fundamentals of Imaging: magnification, resolution, depth of field and depth of focus, etc. Basic principle and components of SEM/EDAX, and TEM./EDAX, Electron diffraction in TEM and its applications, AFM

UNIT VI: - SPECTROSCOPIC TECHNIQUES & THERMAL ANALYSIS:

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

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 analyze acquired knowledge and understanding on effect of grain morphology and its needs for technological advancements
4. To understand advanced microscope techniques.
5. To obtain knowledge on characterization by thermal and non-thermal techniques

Course Code	Course Name	L	Credits
NT 603	Nanotechnology for Defense and Industrial Applications-I	3	3
<p>Course Objectives: The main objectives of this course are to:</p> <ol style="list-style-type: none"> 1. To understand the role of nanomaterials for defence applications 2. To understand the role of nanotechnology in sensor, armor protective system, propellants, pyro-techniques, corrosion, fire retardancy, cosmetics, catalysis, pharma, agriculture, food, 3. To understand the application of nano materials in industry 			
<p>UNIT I: Introduction to nano-energetic materials; Applications of nano materials in ammunition, energetic materials, Nano-thermites.</p> <p>UNIT II: Nanotechnology in stealth and armor protective system</p> <p>UNIT III: Chemical and biological warfare: Nano materials in detection and decontamination of CW and BW agents</p> <p>UNIT IV: Nano materials in thermoelectric and piezoelectric sensing, nanotechnology in sensor, armor protective system, corrosion, cosmetics, catalysis, pharma, agriculture, food tech.</p> <p>UNIT V: Nano Coating and Nano composites for industrial Application</p>			
<p>Course Outcomes</p> <ol style="list-style-type: none"> 1. To understand various applications of nanomaterials in ammunitions and related energetic applications of nanoparticles. 2. To understand the basic difference between nano verses macro particles in terms of their applications. 3. To understand how nanoparticles used in detection and decontamination of chemical and biological warfares. 4. Understand the application of nano particles in industries. 			
<p>Reference Books</p> <ol style="list-style-type: none"> 1. Nanotechnology for Defence Applications, Narendra Kumar, Ambesh Dixit, Springer, 2019. 2. Nanotechnology for Chemical and Biological Defense, Margaret Kosa-I 2009, Springer 3. Nanotechnology in the Defense Industry: Advances, Innovations and Practical Applications, Madhuri Sharon, Angelica S. L. Rodriguez, Chetna Sharon, Wiley, 2019. 			

Course Name Code	Credits
NT-604 Nano materials for Energy and Environment	3

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

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 -CO2 emission -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. Photovoltaic solar cells. Thermoelectric systems, DSSC- Quantum dots based solar cells., EMI Shielding applications of nanomaterials

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

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 -

UNIT.V:- EMERGING TECHNOLOGIES FOR ENVIRONMENTAL REMEDIATION AND PHOTOCATALYSIS

Use of nanoparticles for environmental remediation and water treatment-Role of dendrimer-single enzyme-nanoparticle and metalloprotein. Case studies and Regulatory needs. Degradation of the dye - nanomaterials based photocatalyst design -kinetics of degradation.

Course Outcomes	
<ol style="list-style-type: none"> 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 environment 	
Reference Books	
<ol style="list-style-type: none"> 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, CRC Press, 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	Credits
NT612	Laboratory Practical I	03
	<ol style="list-style-type: none"> 1. Training on wet-chemical laboratory practices 2. Preliminary exposure to various analytical tools 3. Synthesis of Silver nano-particles by chemical method 4. Synthesis of metal NPs using plant extract 5. Analysis of Noble metal NPs by UV-Visible spectroscopy 6. Sol-gel method for MO NPs 7. Analysis of NPs by XRD 8. Synthesis of II-VI semiconductor nano-particles 9. Synthesis of QDs (CdS/CdSe/CdTe) 10. Analysis of QDs by UV/PL 11. Synthesis of carbon QDs 12. Optical Properties of carbon QDs (UV/PL) 13. Calculation of band-gap energy in semiconductor NPs 14. Industrial/Instructional visit-1 	

SEMESTER -II

Course Code	Course Name	Credits
NT-621	Nanobiotechnology	3
Course Objectives: The main objectives of this course are to: <ol style="list-style-type: none">1. Understanding the basic of Biology and Nano science and differentiate between nanomaterials and bulk materials2. Evaluate and critically review the theoretical and practical aspects of Nano materials application3. Comprehending the novel function resulted from the nanoscale structures using scientific and technological principles in Nano biotechnology		
UNIT I: Introduction, History & Applications, various definitions and Concept of bio and Nano- biotechnology, Cell-Nanostructure interactions, Proteins, DNA based nanostructure.		
UNIT II: Biological methods for synthesis of nanoparticles, surface functionalization- and plants extracts and microorganism utility in nanomaterials/biomaterials.		
UNIT III: Various applications of Nano-biotechnology, Devices based on nano biotechnology- and their applications, lab on a chip.		
UNIT IV: Biomedicine and applications of Nanotechnology in Drug Delivery and bioinformatics, Nano materials for 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 Bosco Gueguim-Kana, Nandita Dasgupta 2021, Springer.

Course Code	Course Name	Credits
NT 622	Nanotechnology for Defense and Industrial Applications-II (NBC Warfare: Concepts & Remediation)	3

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
5. Scope of nanomaterials in NBC

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, detection techniques of radiations, scope of nanomaterials in detection.

UNIT III: 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, **Radiological** weapon

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

Course Outcome

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

Course Code	Course Name	Credits
NT 623	Nano Electronics and IT, AI, ML	3
<p>Course Objectives: The main objectives of this course are to:</p> <ol style="list-style-type: none"> 1. To understand the basic Electronics and IT, AI, ML for nanotechnology 2. To demonstrate and understand techniques for Electrical, optical and sensoric devices. 3. To understand general information technology, IoT, electrical and electronics techniques. 		
<p><u>UNIT I: IT, AI, ML</u></p> <ul style="list-style-type: none"> ➤ Introduction to AI & ML ➤ Data Sets, Feature Engineering, Machine Learning Algorithms ➤ Classification and Regression, Artificial Neural Networks ➤ Deep Learning, Large Language Models and Applications ➤ Augmented Reality, Virtual Reality <p>UNIT-II: ENERGY BAND- SCHRODINGER EQUATION SELF-CONSISTENT SOLUTION: $E(p)$ or $E(k)$ relation, density of states, number of modes, electron density (n), quantum wells, wires, dots, nanotubes, conductivity vs. electron density (n), quantum capacitance, the nano transistor boundary condition, Quasi-Fermi Levels (QFL's), Landauer formulas, electrostatic potential, Boltzmann Equation, Spin Voltages. Hydrogen atom, method of finite differences, wave equation, differential to matrix equation, dispersion relation, counting states, Beyond 1-D, Basis functions, Graphene, Reciprocal Lattice / Valleys, self-consistent field (SCF) procedure.</p> <p>UNIT-III: NON-EQUILIBRIUM GREEN'S FUNCTION (NEGF) FORMALISM: Semiclassical model, quantum model, equations, current operator, scattering mechanisms, transmission, resonant tunneling, dephasing, local density of states [LDOS].</p> <p><u>UNIT IV:</u> Device Fabrication e.g. Solar cells, LEDs, EMI by VNA, Thermoelectric Generators, Resistive Sensors, Optical Sensor, Chemical Sensors and diagnostics from Physics, Chemistry and Electronics</p>		
<p>Course Outcomes</p> <ol style="list-style-type: none"> 1. To understand the IoT, AI and ML in Nanomaterials and Nanotechnology. 2. To obtain knowledge on electrical and magnetic characterization techniques. 3. To obtain knowledge on Practical Applications of nanomaterials 4. To learn methods for fabrication of thin/thick films, and conductive layers 		
<p>Text Books</p> <ul style="list-style-type: none"> ➤ Russel and Norvig, "Artificial Intelligence : A Modern Approach", 4th Edition, Pearson. ➤ Steven Lavalley, "Virtual Reality". Cambridge University Press, 2023 		
<p>Reference Books</p> <ol style="list-style-type: none"> 1. Russel and Norvig, "Artificial Intelligence : A Modern Approach", 4th Edition, Pearson. 2. Steven Lavalley, "Virtual Reality". Cambridge University Press, 2023 		

Course Code	Course Name	Credits
NT 624	Nano-Safety, Health & Hazard	3
<p>Course Objectives: The main objectives of this course are to:</p> <ol style="list-style-type: none"> 1. To understand the principles of standards and regulations of nano-safety related to handling, storage and health hazards 2. Know prerequisites of the safety principles in management of modern laboratories. 3. Be able to use these principles and methods in analyzing and solving problems of work /production/application place 		
<p><u>UNIT I: CHEMICAL SAFETY:</u> 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</p> <p><u>UNIT II: HAZARD MANAGEMENT:</u> HAZOP and HAZAN techniques, Hazard in manufacture, Hazard prevention measures, Disposal of hazardous materials</p> <p><u>UNIT III: Nano-toxicity and Nano-safety & health :</u> Classifications of nano-toxicity and safety, precautions, remediation and implementation, Nano materials safety, handling & demonstration of air-sensitive, pyrophoric and toxic chemicals</p> <p><u>UNIT IV: Protection from nanomaterials hazards,</u> Assessment of human factors, Health & Environment safety</p> <p>(Tutorials/ Practical's/ Seminars)</p> <ol style="list-style-type: none"> 1. Handling and demonstration of air sensitive, pyrophoric and toxic chemicals 2. Monitoring of effluents through Gas chromatography / Ion chromatography 		

Course Outcomes
<ol style="list-style-type: none"> 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
<ol style="list-style-type: none"> 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	Credits
NT613	Laboratory Practical II	03
	<ol style="list-style-type: none"> 1. Technique(s) for thin film deposition of NPs 2. Nano-particles/Polymer composites and their electrical measurements 3. EMI shielding behaviour of NPs 4. I-V characteristic studies of semiconductors NPs 5. Gas sensing through MO NPs 6. Photocatalysis Experiments using NPs 7. Degradation of explosive/energetic chemicals using NPs 8. THz measurement involving NPs 9. Experiments related to nano-electronics 10. Experiments related to nano-electronics 11. Fabrication technique for QDs LED 12. Experiments related to nano-biotech 13. Industrial/Instructional visit-2 	