Scheme of Examination

&

Syllabus

of

Master of Technology

in

Nano Science & Technology

Academic Year: 2021-2022 onwards

University School of Basic & Applied Sciences
Guru Gobind Singh Indraprastha University
Sector 16C, Dwarka, Delhi 110078

Approved in the 50th meeting of the academic Council of GGSIP University held on 11/06/2021 vide agenda item AC 50.22

Scheme of Examination of M.Tech. Nano Science & Technology

Programme Education Objectives (PEO)

PEO1. Students with diverse educational backgrounds are converged to a common stream of nanoscience and nanotechnology.

PEO2. Programme focuses on strengthening the fundamentals of physical and chemical sciences and gradually transcends towards the application aspects of this fast growing and intriguing field.

PEO3. The laboratories are designed to strengthen the experimental skills of the students on synthesis & fabrication of nanomaterials, study some of their important properties and to provide the students hands on training on the equipments.

PEO4. The students are encouraged towards self-learning, literature survey, designing experiments and carrying out projects under close guidance of faculties.

Programme Outcomes (PO)

PO1. Students develop the essential skill sets for synthesizing, studying and applying the nanomaterials to meaningful practical purposes and develop useful devices.

PO2. Extensive interaction with the faculties and exhaustive discussions/ presentations throughout the course of the programme aids the students towards critical thinking and enhances their overall presentation & communication skills.

PO3. Summer training, minor & major projects in other research institutes and universities expose the students to various research environments enabling them for future research & opening placement avenues.

PO4. After completion of the programme our students will not only be "Research Ready" for industries and academia but also will be adequately sensitized towards society and environment.

Mapping between PEO and PO (on a scale of 1-10, with 10 excellent)				
	PEO_1	**PEO_2**	**PEO_3**	**PEO_4**
PO_1	8	8	8	8
PO_2	8	8	8	8
PO_3	9	8	9	8
PO_4	8	8	9	9

Semester - I Credit: 26

S. No.	Course Code	Title of the Course	Credits	Remarks L/T/P
1.	NST-101	Elements of Physics	4	4/0/0
2.	NST-103	Elements of Physical Chemistry	4	4/0/0
3	NST-105	Elements of Material Science and Nanoscale Properties	4	4/0/0
4.	Program Specific Elective I (any one)			
	NST-107	Microorganisms and Bionanocomposites	4	4/0/0
	NST-109	Nanotoxicology	4	4/0/0
5.	NST-111 (EMES-611)	Environmental Studies	2	2/0/0 (NUES)
6.	NST-151	Laboratory-I	3	0/0/6
7.	NST-153	Laboratory-II	3	0/0/6
8.	NST-155	Self-Study-I*	2	0/2/0

L = Lecture, T = Tutorial, P = Practical

NUES => Non University Examination System

*Self-Study-I: Presentations will be made by the students on relevant topics assigned and supervised by the faculty. The presentations will be subjected to internal and external evaluations.

Semester - II Credit: 28

S. No.	Course Code	Title of the Course	Credits	Remarks L/T/P
1.	NST-102	Fabrication Techniques and Characterisation of Nanomaterials	4	4/0/0
2.	NST-104	Soft Synthetic Routes & Novel Nanomaterials	4	4/0/0
3.	NST-106	Nanodevices & Nanosensors	4	4/0/0
4.	Program Specific Elective II (any one) NST-108 NST-110	 Solutions & Surface Phenomena Surface & Supramolecular Chemistry	 4 4	 4/0/0 4/0/0
5.	NST-112 (HVE-102)	Human Values and Ethics	2	2/0/0 (NUES)
6.	NST-114 (USMS112)	Entrepreneurial Mindset	2	2/0/0 (NUES)
7.	NST-152	Laboratory-III	3	0/0/6
8.	NST-154	Laboratory-IV	3	0/0/6
9.	NST-156	Self-Study-II**	2	0/2/0

NUES => Non University Examination System

**Self-Study-II: Presentations will be made by the students on emerging topics assigned and supervised by the faculty. The presentations will be subjected to internal and external evaluations.

***The students will proceed for Summer Training at the end of second semester for a period of 6-8 weeks. The students will then submit the training report after its completion and make a presentation which will be subjected to internal and external evaluations.

Semester - III Credit: 26

S. No.	Course Code	Title of the course	Credits	Remarks L/T/P
1.	NST-201	Carbon Nanostructures	4	4/0/0
2.	Program Specific Elective III (any one)			
	NST-203	Nanomagnetism	4	4/0/0
	NST-205	Computational Nanoscience	4	4/0/0
	NST-207	Nanofabrication with Ion Beams	4	4/0/0
3.	Program Specific Elective IV (any one)			
	NST-209	Photonics & Plasmonics	4	4/0/0
	NST-211	Nanomedicine	4	4/0/0
	NST-213	Nanocomposites	4	4/0/0
4.	NST-215 (Open Elective#)		4	4/0/0
5.	NST-217	Computational Laboratory	2	0/0/4
6.	NST-251	Minor Project##	5	--
7.	NST-253	Summer Training*** (Viva-voce)	3	--

NUES => Non University Examination System

Open Elective courses will be chosen from the Programmes of Study offered in any University School of Studies (USS), which have an appropriate relevance to M.Tech. (NST) programme.

In the Minor project the students become increasingly focused towards their research interests, take one particular problem and carry out experimental or theoretical study. The project is examined for internal evaluation followed by an external examination involving a presentation and submission of project report.

All the theory courses will be open to other programmes of USBAS including Ph.D. coursework.

The Programme Specific Electives will be open to programmes of other USS, wherever relevant.

Semester - IV Credit: 25

S. No.	Course Code	Title of the Course	Credits	Remarks
1.	NST-202	Major Project / Dissertation	20	--
2.	NST-204	Comprehensive Viva Voce	5	NUES

NUES => Non University Examination System

Major Project will be undertaken by students in either experimental or theoretical work. It could be carried out either in-house, i.e., involving the University Schools and facilities or in industry/ research organizations for a period of 6 months along with the preparation of a dissertation. In both cases an internal supervisor from the USBAS is mandatory and an external collaborating supervisor can be involved if needed. The project will be examined for internal evaluation followed by an external examination involving a presentation and final submission of dissertation. Original work leading to a publication will be encouraged.

Comprehensive Viva Voce is an internal and external evaluation via a viva voce covering all aspects of the programme including the major project.

Note:

1. Total No. of credits of the program is equal to 105 credits.
2. Students shall be required to appear for examinations in all courses.
3. Programme Specific Electives and Open Electives will be governed by the available courses being floated in the relevant semester by USBAS and other USS.
4. For the award of the degree a student should secure at least 100 credits. The dropping of Programme Core courses will not be permitted.
5. Three courses namely (a) Environmental Sciences, (b) Human Values and Ethics, and (c) Entrepreneurial Mindset are mandated for all programmes run by the GGSIP University.

Scheme of Exams/Evaluation

All Theory Papers will have continuous internal evaluation (based on minor exams, quiz, attendance, regularity, presentations etc.) and a final end semester exam conducted by the examination. All Practical papers will also have continuous internal evaluation and a final end semester exam. While the current division is of 25% internal and 75% for theory papers and 40% internal and 60% final end semester examination for practicals, this division will change as per the policies adopted by the university/university schools from time to time on the continuous evaluation process and end term examinations.

Total Credits: 105

Credits Required for the Degree: 100

Elements of Physics

Course Code : NST 101 L- 04 Credits– 04

Course Objectives:

CO_1	To develop familiarity with the physical concepts and the mathematical methods of quantum mechanics.
CO_2	To understand the concepts of concepts of spin and angular momentum, as well as their quantization and addition rules and application of quantum mechanics to physical situations.
CO_3	To understand the introductory concepts of statistical mechanics.
CO_4	To understand both classical and quantum regime of statistical mechanics. The description of quantum statistics is nonmathematical in this course.

Course Contents:

Unit I: Quantum Mechanics-I: (10 hours)
Schrödinger equation and expectation values, Solutions of the one-dimensional Schrodinger equation for free particle, particle in a box, particle in a finite well, linear harmonic oscillator. Reflection and transmission by a potential step and by a rectangular barrier.

Unit II: Quantum Mechanics-II: (12 hours)
Solution of Time independent Schrödinger equation at higher dimensions and more complicated systems Particle in a three dimensional box, linear harmonic oscillator and its solution, density of states, free electron theory of metals. The angular momentum problem. The spin half problem and properties of Pauli spin matrices.

Unit III: Statistical Mechanics-I: (10 hours)
Introduction to Statistical Mechanics, Microstates and Macrostates,Entropy and its statistical definition, Entropy of mixing, Gibb's free energy, Gibb's paradox, Phase space density, Ergodic hypothesis, Liouville's theorem.

Unit IV: Statistical Mechanics-II: (12 hours)
Microcanonical-, Canonical- and Grand Canonical- ensembles, idea of partition function and it's uses, Fluctuations, Classical Statistical systems, Maxwell-Boltzman statistics, Quantum statistical systems: Fermi-Dirac and Bose-Einstein Statistics and their applications (An overview).

Suggested Readings and References

1. Quantum Mechanics: Theory and Applications - Ajoy Ghatak, S. Lokanathan, 6th Edition, Trinity Press Publication, 2012.
2. Introduction to Quantum Mechanics - David J. Griffith and Darrell F. Schroeter, 3rd Edition, Cambridge University Press, 2018.
3. Quantum Mechanics - B. H. Bransden and C. J. Joachain, 2nd Edition, Pearson Education, 2000.
4. Thermodynamics and Statistical Mechanics - John M. Seddon, J. D. Gale, RSC Publication, 2002.

5. Introduction to Statistical Physics - K. Huang, 2nd Edition, CRC Press, 2009.
6. Statistical Mechanics Vol 5 - Landau & Lifshitz, 3rd Edition, Elsevier Science, 2013.

Course Expected Outcomes:

CEO_1	The students will be able to formulate and solve physics problems using quantum mechanics.
CEO_2	The students will be able to grasp the concepts of spin and angular momentum, as well as their quantization and addition rules.
CEO_3	The students will be able to grasp the elementary classical statistics so that they can describe equilibrium systems.
CEO_4	The students will have idea of ensembles, classical and quantum statistics and their applications.

Elements of Physical Chemistry

Course Code : NST 103 L- 04 Credits– 04

Course Objectives:

CO_1	The purpose of this paper is to provide the students an overview of the important concepts of physical chemistry. Enabling the students to understand and appreciate the significance of the basic tools.
CO_2	Thermodynamics and its application in phase rule are central to understand a large number of related applications. The emphasis here is to strengthen these concepts.
CO_3	The concepts of electrochemistry, chemical kinetics and photochemistry are fundamental and useful in understanding the processes involved in optical devices, smart coatings, electrochemical sensors, etc..
CO_4	For making any advances in high end materials, material science lies at the core keeping this in consideration, this paper also covers a detailed unit on diffusion in solids.

Course Contents:

Unit I : Chemical Bonding: (8 hours)
Atomic Bonding in Solids, Types of bond: Metallic, Ionic, Covalent and vander Waals bond, Hybridisation, H- bonding, Theories of bonding in metals- Free Electron, Valence Band and Molecular Orbital theory.

Unit II :Thermodynamic and Solutions: (14 hours)
Overview to Thermodynamics: The first and second laws of thermodynamics, Thermodynamic functions, heat capacity, enthalpy, entropy.
Phase rule: Phase equilibrium in one component system, real gases, interactions between gases,Ehrenfest classification of phase transition,physical liquid surface, surface tension,curved surfaces, capillary action.
Solutions: Theory of Solutions, Liquid mixtures, free energy as a function of composition,ideal solutions and excess functions.

Unit III: Overview of Dynamic Phenomena: (12 hours)
An Overview of Chemical Kinetics: First and second order kinetics, introduction to Collision Theory and Activated Complex theory.
Equilibrium Electrochemistry: Electrochemical cells, Methods for calculation of thermodynamic equilibrium and Electrochemical processes.
Photochemistry: Introduction, Quantum yield, Jablonski diagram and quenching, Photochemistry of nanomaterials.

Unit IV: Diffusion in Solids: (10 hours)
Fick's Law, Mechanisms of Diffusion, generation of point defects, self-diffusion, influence of the pressure and pressure gradient,Kirkendall effect, fast diffusion, influence of isotropic state, experimental methods of investigation of diffusion.

Suggested Readings and References

1. Elements of Physical Chemistry - Atkins Peter, Paula Julio, 8th International Edition, W.H. Freeman & Company, 2006.
2. Principals of Physical Chemistry - Marron-Pruton, 4th Edition, The Macmillan Company, 1964.
3. Physical Chemistry - David W. Ball, Cengage, 2015.
4. Physical Chemistry - K. L. Kapoor, 6th Edition, Mc Graw Hill, 2019.
5. Material Science and Engineering - V. Raghavan, 5th Edition, PHI, 2019.

Course Expected Outcomes:

CEO1	The student should be able to acquire a detailed understanding of the structure and interactions of atoms and molecules that are essential to understand the complex behaviour of matter and hence nanomaterials around us.
CEO2	The students should be able to apply the concepts of Thermodynamics, Phase Equilibrium, Solution Thermodynamics, Kinetics and photochemistry to design systems and preparation of materials with desirable properties via most efficient routes.
CEO3	Diffusion of solids in an extremely important phenomenon to obtain desired properties in materials. Control of factors influencing diffusion in solids will equip the students with this important phenomenon.
CEO4	This paper will give the students a strong fundamental grasp over all these important concepts of physical chemistry, which they should be able to apply when dealing with real life systems.

Elements of Material Science & Nanoscale Properties

Course Code : NST 105 **L- 04** **Credits– 04**

Course Objectives:

CO_1	To provide students understanding of the crystal structures and importance of defects in materials.
CO_2	To enable the students to understand the electronic properties of materials.
CO_3	To understand the basics of dielectric properties of materials.
CO_4	To enable the students to understand the optical properties of nanomaterials.

Course Contents:

Unit I : Solid State Physics (Overview): (10 hours)
Structure of Solids: Amorphous, Crystalline, Crystals, Polycrystals, Symmetry, Unit Cells, Crystal Structures (Bravais Lattices), Crystallographic Directions, Crystallographic Planes, Miller Indices, Bragg's Law, X-ray Diffraction.
Defects in Solids: Point defects, Grain boundaries, Phase boundaries, Dislocations: Screw, Edge and Mixed Dislocations, Generation of defects: by quenching, by plastic deformation and by radiation, Interaction between point defects and dislocations.

Unit II : Electronic Properties: (12 hours)
Classification of Materials: Metals, Semiconductors, Insulators, Band structures, Brillouin zones, Mobility, Resistivity, Relaxation time, Recombination Centers, Hall Effect.

Unit III: Dielectric properties: (10 hours)
An overview of Polarization, Ferroelectric behavior, Piezoelectric and Pyroelectric materials at nanoscale.

Unit IV: Optical Properties: (12 hours)
Quantum Confinement, Photoconductivity, Optical Absorption & Transmission, Photoluminescence and fluorescence from direct band gap semiconductor nanoparticles, light emission from indirect band gap semiconductors, light emission from Si nanodots, Electroluminescence and LED.

Suggested Readings and References

1. Introduction to Solid State Physics - Charles Kittel, 8th Edition, John Wiley & Sons, 2004.
2. Solid State Physics- A.J. Dekker, 1st Edition, Macmillan, 2000.
3. Solid State Physics - S.O. Pillai, 9th Edition, New Age International, 2020
4. The Physics and Chemistry of Solids - Stephen Elliott & S. R. Elliott, John Wiley & Sons, 1998.
5. Structures and Properties of Solid State Materials - B. Viswanathan, Alpha Science, 2006.
6. Basic Solid State Chemistry - Anthony R. West, 2nd Edition, Wiley–Blackwell, 1999.

Approved in the 50th meeting of the academic Council of GGSIP University held on 11/06/2021 vide agenda item AC 50.22

Course Expected Outcomes:

CEO_1	The students will be able to describe the crystal structures and defects in the different classes of materials.
CEO_2	This will strengthen their fundamental understanding of the electronic properties of materials.
CEO_3	The students will have a good understanding of the dielectric properties of materials.
CEO_4	The students will have good fundamental grasp over the optical properties of nanomaterials.

Microorganisms and Bionanocomposites

Course Code : NST-107 L- 04 Credits– 04

Course Objectives:

CO_1	To enable students to be competent in biological methods of nanoparticle preparation
CO_2	To enable the students to understand the role of microorganism for toxicity detection of nanomaterials
CO_3	To enable the students to understand natural nanocomposites with a view to understand nanocomposites for bone and teeth replacement
CO_4	To enable the students to learn about Nanobio Systems

Course Contents:

Unit I: Biological Methods of Synthesis: (12 hours)
Use of bacteria, fungi, Actinomycetes, Yeast for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles, Mechanism of formation, Viruses as components for the formation of nanostructured materials, Role of plants in nanoparticle synthesis, Phytoremediation

Unit II: Microorganisms for Toxicity Detection: (10 hours)
Ecotoxicity and Bioassay, Testing of environmental toxic effect of nanoparticles using microorganisms

Unit III: Nanocomposite Biomaterials: (12 hours)
Natural nanocomposite systems as spider silk, bones, shells, Organic-inorganic nanocomposite formation through self-assembly, Biomimetic synthesis of nanocomposite material, Use of synthetic nanocomposites for bone, teeth replacement.

Unit IV: Nanobio Systems: (10 hours)
Nanoparticle-biomaterial hybrid systems for bioelectronic devices, Biomaterial nanocircuitry, DNA based computation; DNA based nanomechanical devices, Biosensor and Biochips, Targeted Drug Delivery, Molecular Imaging using nanoparticles.

Suggested Readings and References

1. Nanobiotechnology: Concepts, Applications and Perspectives - C.M. Niemeyer, C.A. Mirkin, Wiley-VCH, ISBN: 978-3-527-30658-9, 2004.
2. Bionanotechnology: Lessons from Nature - David S. Goodsell, Wiley, ISBN: 978-0-471-41719-4, 2004.
3. Introduction to Nanotechnology - R. Singh, S. M. Gupta, Oxford University Press, ISBN:9780199456789, 2016.
4. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology - Hari Singh Nalwa, American Scientific Publishers, ISBN: 1-58883-004-7, 2005.

Approved in the 50th meeting of the academic Council of GGSIP University held on 11/06/2021 vide agenda item AC 50.22

Course Expected Outcomes:

CEO_1	The students will learn the biological methods of nanoparticle synthesis which help them to be able to synthesize nanoparticles in a green way in laboratory/industry.
CEO_2	The students understand toxicity issues related to the use of nanomaterials and the role of microorganisms in assessing them
CEO_3	The students will study the properties of natural nanocomposite systems, which is helpful in taking inspiration and producing products having superior properties using greener techniques
CEO_4	The students will understand some nanoparticle-biomaterial hybrid systems which helps them to design hybrid systems for bioelectronic devices, computing and nanomechanical devices etc.

Nanotoxicology

Course Code : NST 109 **L- 04** **Credits – 04**

Course Objectives:

CO_1	To appraise the students about the toxic impact of nanoparticles and to know the basic equipments to be used in the laboratories for safe handling of these materials.
CO_2	To help the students understand the various entry-routes of nanoparticles in human body and their impact.
CO_3	To teach the students about biotoxicity of a wide variety of nanomaterials.
CO_4	To study the dosimetry and toxicity of nanomaterials.

Course Contents:

Unit I: Toxicity of Nanomaterials and Proper Handling: (10 hours)
Fate of Nanomaterials, Nanomaterial toxicity and testing, Occupational Exposure Risk, Risk assessment and handling of engineered nanomaterials. Recommendations for Exposure Control - Elimination / Substitution, Isolation and Engineering Controls, Administrative Controls, Personal Protective Equipment. Local Exhaust Ventilation - Chemical Hoods, Glovebox Enclosures, Biological Safety Cabinets, Powder Handling Enclosures. Cleanup and disposal of nanomaterials, Fire and Explosion Control, Prevention and control of Nanomaterial Spills.

Unit II: Possible Health Impact of Nanomaterials: (11 hours)
Sources of Nanoparticles; Epidemiological Evidence; Entry Routes into the Human Body – Lung, Intestinal Tract, Skin; Nanoparticle Size - Surface and Body Distribution in context of Size and Surface Charges of Nanoparticles, Thrombosis and Lung Inflammation; Nanoparticles and Cellular Uptake; Nanoparticles and the Blood Brain Barrier.

Unit III: Biotoxicity of Nanomaterials: (11 hours)
Environmental Influence of Toxicology of Nanomaterials, Routes of Administration and Potential Health Effects, Oxidative Stress, Inhalation and Cytotoxicity, Nanotechnology and Strategies to Ensure Occupational Health. Toxicological Studies and Toxicity of metal and metal oxide nanoparticles, carbon-based nanomaterials, silica nanoparticles, polymeric nanoparticles.

Unit IV: Dosimetry, Epidemiology and Toxicology of Nanoparticles: (12 hours)
Epidemiological Evidence for Health Effect Associations with Ambient Particulate Matter; Toxicological Evidence for Ambient Particulate Matter Induced Adverse Health Effects; Inhaled Nanoparticle Dosimetry; Toxicological Plausibility of Health Effects Caused by Nanoparticles; Integrated Concept of Risk Assessment of Nanoparticles. Effects of Nanoparticles on Pulmonary System; Cardiovascular System; Nervous System, Liver and Gastrointestinal Tract.

Suggested Readings and References

1. Nanomaterials - Toxicity, Health and Environmental Issues - Challa. S. S. R, Kumar, Wiley-VCH publisher, 2006.

2. Nanotoxicology: Characterization, Dosing and Health Effects- Nancy. A, Monteiro-Riviere, Lang Tran. C Informa healthcare, 2007.
3. Nanotoxicology for safe and Sustainable Nanotechnology - Drobne. D, Dominant publisher, 2007.
4. A Reference handbook of nanotoxicology - Zafar Nyamadzi. M, Dominant publisher, 2008.
5. Nanotoxicology: Toxicity Evaluation, Risk Assessment and Management- Vineet Kumar, Nandita Dasgupta, Shivendu Ranjan, CRC Press, 2018.

Course Expected Outcomes:

CEO_1	The students will learn about the toxic impact of nanoparticles and safe handling of these materials.
CEO_2	The students will able to understand understand the various entry-routes of nanoparticles in human body and their impact.
CEO_3	The students will learn about biotoxicity of a wide variety of nanomaterials.
CEO_4	The students will learn about nanoparticle dosimetry and the impact of toxic nanomaterials.

Environmental Studies

Course Code : NST -111 (EMES-611) L- 02 Credits– 02 NUES

Course Objectives:

CO_1	The course is designed to impart basic knowledge of the environment and its components.
CO_2	The course deals in creating awareness about the environment, existing organisms, the energy resources and current environmental problems faced by the world.
CO_3	To understand and explore different approaches of conserving and protecting environment for the benefit of society.

Course Contents:

Unit I: Fundamentals: The Multidisciplinary nature of environmental studies: Definition, scope and importance, need for public awareness:
Ecosystems: Structure and function of an ecosystem, energy flow in ecosystems, food chain, food web, ecological pyramids, ecological succession; Introduction to types & characteristics.
Biodiversity: Introduction to biodiversity-definition, genetics, species, ecosystem diversity, value of biodiversity-consumptive uses, productive, social, ethical, aesthetic and option values, biodiversity at global and national level, hot spots of biodiversity in India, threats to biodiversity, in-situ and ex-situ conservation. (7 hours)

Unit II: Renewable and non renewable resources: Energy resources: Growing energy needs, renewable and non renewable energy sources, sustainable development
Water Resources: Use and over-utilization of surface and ground water, conflicts over water
Forest resources: Use and over-exploitation, deforestation, case studies
Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies
Food resources: World food problems, changes caused by agriculture and over-grazing, effects of modern agriculture, fertilizer-pesticide problems
Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification. **(5 hours)**

Unit III: Environment Pollution: Air Pollution**:** Types of pollutants, sources, effects & control of air pollutants.
Water Pollution: Classification of Pollutants, their sources, waste water treatment
Soil Pollution: Composition of soil, classification and effects of solid pollutants and their control.
Solid Waste Management: Classification, waste treatment and disposal methods; compositing, sanitary land filling, thermal processes, recycling and reuse methods.
Hazardous wastes - Classification, treatment and disposal processes.
Marine Pollution: Causes, effects and control of marine pollution, coastal zone management.
Thermal pollution: Causes, effects and control of Thermal pollution **(5 hours)**

Unit IV: Social Issues, Human Population and Environment Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents, Environmental Impact Assessment; Some

important Environmental laws, Green bench; population growth and variation among nations, environment and human health, human rights, value education, women and child welfare, Role of government and non government organizations in environment improvement.

(6 hours)

Field work

Suggested Readings and References

1. Textbook of environmental studies, Erach Barucha, UGC, 2013
2. Fundamental concepts in environmental studies, DD Mishra, S Chand & Co Ltd, 2014
3. A textbook of environmental studies, R Gadu, S Rattan, S Mohaptra, Kataria Publication, 2016
4. Basics of Environment and Ecology, A. kaushik & C.P.Kaushik, New Age International Publishers, 2010.
5. Elements of environmental sciences & engineering, P Meenakshi, PHI Learning Pvt Ltd, 2014
6. Environmental studies, B Joseph, Tata McGraw-Hill Publishing Company Ltd., 2012
7. Environmental chemistry, Sharma & Kaur, Goel Publishing House, 1995
8. Environmental Studies, Franky Varah, Mahongnao P., Khashimwo P. and Shimrah. T. Heritage Publishers, New Delhi, 2020

Course Expected Outcomes:

CO_1	Environmental Studies course will provide necessary information and knowledge about the various aspects of environment, ecosystems and related biodiversity.
CO_2	Students will be able to learn and understand about the availability and sustainable use of resources, environmental problems and their short term and long term impacts to humans.
CO_3	Course will help them to learn about various social issues and role of human in conservation and protection of our environment.

Laboratory-I

Course Code : NST 151 **P- 6** **Credits– 03**

Course Objectives:

CO_1	The objective is to bring students from various streams to a common point by real time hands-on practicals, so that they come to understand simple underlying physical and chemical principles. The experiments designed are simple and the students are expected to observe and learn.
CO_2	This lab particularly touches upon some fundamental concepts of experimental physical chemistry, which are important in understanding and interpreting more complex phenomena.
CO_3	The students will undergo hands-on training on various equipments for synthesizing and characterizing nanomaterials.
CO_4	They also learn detailed writing, data analysis and discussion of results. This is the first step towards developing a research oriented mindset.

Course Contents:

List of experiments (will be updated from time to time) from which selected experiments will be performed:

1. To study kinetics of hydrolysis of an ester.
2. Effect of surfactant concentration on equivalent conductance and determination of critical micelle concentration (CMC).
3. Verification of Lambert Beer's law and determination of concentration of unknown solution by UV-visible spectrophotometer.
4. Preparation of colloidal silver nanoparticles with trisodium citrate and their characterization by UV-visible spectroscopy.
5. To study Hydrogen bonding by FTIR spectroscopy.
6. Preparation of metal oxide nanoparticles by micro emulsion technique.
7. Characterization of prepared metal oxide nanoparticles by XRD and determination of their size using Scherrer's formula.

Course Expected Outcomes:

CEO_1	Students from various backgrounds are expected in the course. After the first semester, they will develop a feel about the common tools used in real life nanoscience work such as DLS, XRD, FTIR, UV-Vis spectroscopy to name a few. They will start developing and consolidating simple ideas from Chemistry, needed to go forward.
CEO_2	They will learn various chemical techniques involved in synthesis of nanomaterials.
CEO_3	They will learn to study some fundamental physical parameters such as bandgap, particle size determination, identification of hydrodynamic radius, fingerprinting with UV-Vis-NIR, FTIR and XRD.

CEO_4	They will be become verse with report writing, data analysis and discussion of results.

Laboratory-II

Course Code : NST 153 **P- 6** **Credits– 03**

Course Objectives:

CO_1	The objective is to bring students from various streams to a common point by real time hands-on practicals, so that they come to understand simple underlying physical and chemical principles. The experiments designed are simple and the students are expected to observe and learn.
CO_2	This paper focuses on enabling students to synthesize nanomaterials by different physical and chemical methods.
CO_3	The students will undergo hands-on training on various equipments for synthesizing and characterizing nanomaterials.
CO_4	They also learn detailed writing, data analysis and discussion of results. This is the first step towards developing a research oriented mindset.

Course Contents:

List of experiments (will be updated from time to time) from which selected experiments will be performed:

1. Synthesis of zinc oxide nanoparticles by precipitation method and characterize using UV-visible absorption spectroscopy and X-ray diffraction
2. Synthesis of Mn doped zinc oxide nanoparticles and characterize using UV-visible absorption spectroscopy and X-ray diffraction
3. Synthesis of copper oxide nanoparticles by precipitation method and characterize using dynamic light scattering and Raman spectroscopy
4. Synthesis of nickel oxide nanoparticles by precipitation method and determine the average size of nanoparticles using dynamic light scattering and crystallite size using X-ray diffraction
5. Synthesis of Fe_3O_4 nanoparticles and characterize using X-ray diffraction and Raman spectroscopy
6. Deposition of Cu thin films by thermal evaporation and study annealing induced morphological evolution using atomic force microscopy.
7. Preparation and characterization of nanostructured zinc oxide thin films by RF magnetron sputtering.
8. Synthesis and characterization of cobalt ferrite nanoparticles using X-ray diffraction and Raman spectroscopy
9. Preparation of nickel and copper based electroless deposition and characterization of surface morphology with atomic force microscopy.
10. Controlled oxidation and annealing of films of Cu and Ni electroless deposition and characterization by XRD, Raman spectroscopy, Atomic Force microscopy.
11. Study of electrodeposited films of metals on a conducting substrate with AFM and XRD (Cu, Ni, Ag)

Course Expected Outcomes:

CEO$_1$	Students from various backgrounds are expected in the course. After the first semester, they will develop a feel about the common tools used in real life nanoscience work such as DLS, XRD, AFM, Raman Spectroscopy and UV-Vis spectroscopy. They will learn to converge and consolidate simple concepts from Physics and Chemistry, needed to go forward.
CEO$_2$	They will learn various chemical and physical techniques involved in synthesis of nanomaterials.
CEO$_3$	They will learn to study some fundamental physical parameters such as bandgap, particle size determination, identification of hydrodynamic radius, fingerprinting with UV-Vis, Raman spectroscopy, FTIR, XRD.
CEO$_4$	They will learn to observe, study and correlate morphology with various physical and chemical properties of nanomaterials.

Self-Study-I

Course Code : NST 155 **T- 02** **Credits– 02**

Course Objectives:

CO_1	To bring the student's focus on the core area of Nanoscience &Technology, relevant topics from the field are assigned to the students for presentations. These topics are decided by the faculties and are usually those that are not taught in details in various papers but are of immense importance.
CO_2	Students learn to look for useful literature under close guidance of the faculties.
CO_3	Enables the students to develop effective presentation skills
CO_4	Detailed discussions and Q/A session during each presentation provides the students an elementary flavour of the subject and gears them up for a more rigorous training for future.

Course Contents:

Presentations will be made by the students on relevant topics assigned and supervised by the faculty. The presentations will be subjected to internal and external evaluations.

Course Expected Outcomes:

CEO_1	The students will learn how to effectively search, learn and present with a proper representation.
CEO_2	By mutual interaction, the students will learn to widen their horizon of knowledge in the field of nanoscience and technology. Not only they will learn to present, but also they learn to question and discuss.
CEO_3	The students will develop effective presentation skills.
CEO_4	The students will gear up for a more rigorous training.

Fabrication Techniques and Characterisation of Nanomaterials

Course Code : NST 102 **L- 04** **Credits– 04**

Course Objectives:

CO_1	To give students proper exposure to various methods for synthesis of nanomaterials, needed for fabrication of various nanodevices.
CO_2	To know in depth different characterization techniques for characterizing the nanostructures.
CO_3	Application of optical methods for studying nanostructures.
CO_4	Different lithographic techniques and nanomanipulation strategies are to be discussed for fabrication of Nano materials & devices.

Course Contents:

Unit – I: Fabrication of Nanomaterials: (12 hours)
Inert gas condensation, Arc discharge, RF/DC- magnetron sputtering, Ion sputtering, Laser ablation, Laser pyrolysis, Molecular beam epitaxy, Chemical Vapour Deposition method, Electrochemical method, High Energy Ball Milling, Fabrication of semiconductor nanostructures by Vapor-Liquid-Solid and Vapor-Solid techniques.

Unit – II: Structural Analysis: (16 hours)
Scanning Probe Microscopy (SPM), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) and Energy Dispersive Analysis of X-ray, X-ray diffraction

Unit – III: Optical methods: (6 hours)
Optical Microscope and their description, operational principle and application for analysis of nanomaterials, UV-VIS-NIR Spectrophotometers, Principle of operation and application for band gap measurement

Unit – IV: Lithography and Nanomanipulation: (10 hours)
Deep UV lithography, X-ray based lithography, Electron beam lithography, SEM based nanolithography, Ion beam lithography, Nanoimprint, Nanomanipulation.

Suggested Readings and References

1. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM, by R.F. Egerton
2. Nanostructures and Nanomaterials - Synthesis, Properties and Applications- Guozhong Cao.
3. Encyclopedia of Nanoscience and Nanotechnology by Hari Singh Nalwa
4. Nano: The Essentials, by T. Pradeep
5. Physical Chemistry 8th Edition by Peter Atkins, Julio de Paula
6. Quantitative Chemical Analysis by Daniel C. Harris

Course Expected Outcomes:

CEO_1	The students will have grasp on various methods, and their underlying principles for preparing variety of nanomaterials, some of which they will be doing in the lab.
CEO_2	They will also learn the working principles of various characterization techniques to analysis nanomaterials. They will have hands on training on some of these, during the course of program.
CEO_3	An understanding of optical properties will enable the students to correlate the size/shape of nanomaterials with their electronic structure.
CEO_4	A good knowledge of lithographic techniques will enable them to apply these concepts for designing novel nanodevices.

Soft Synthetic Routes & Novel Nanomaterials

Course Code : NST-104 L- 04 Credits– 04

Course Objectives:

CO_1	To enable students to learn the Chemical Routes for Synthesis of Nanomaterials
CO_2	To enable students to understand the properties Nanocomposites
CO_3	To enable students to understand the properties Nanopolymers
CO_4	To enable students to understand the properties of Metal Nanoparticles

Course Contents:

Unit I: Chemical Routes for Synthesis of Nanomaterials: (12 hours)
Chemical precipitation and co-precipitation, Metal nanocrystals by reduction, Sol-gel synthesis,Microemulsions or reverse micelles,Thermolysis route, Microwave heating synthesis,Sonochemical synthesis, Electrochemical synthesis, Radiation-assisted synthesis, Solvothermal/Hydrothermal synthesis, Synthesis in supercritical fluids.

Unit II: Nanocomposites: (12 hours)
Nanocomposites: an introduction, Types of nanocomposites (i.e. metal oxide, ceramic, glass and polymer based), Core-shell structured nanocomposites,Superhardnanocomposites: synthesis, applications and milestones.

Unit III: Nanopolymers: (10 hours)
Nanopolymers, Preparation and characterization of diblockcopolymer based nanocomposites, Nanoparticles polymer ensembles, Assembly of polymer-nanoparticles composite materials, Fabrication of polymer-mediated organized nanoparticles assemblies; Applications of nanopolymers in catalysis

Unit IV: Metal Nanoparticles: (10 hours)
Size control of metal nanoparticles,study of their properties: optical, electronic, magnetic. Surface plasmon band and its application, Role in catalysis, Stabilization in sol, glass and other media, Change of bandgap, Colour change in sol, glass and composites.

Suggested Readings and References

1. Chemistry of Nanomaterials: Synthesis, Properties and Applications - CNR Rao, H.C. mult. Achim Müller, A. K. Cheetham, Wiley-VCH Verlag GmbH & Co. KGaA, ISBN: 9783527306862, 9783527602476, 2004.
2. Nanochemistry: A Chemical Approach to Nanomaterials - Geoffrey A Ozin, André Arsenault, Ludovico Cademartiri, Edition 2, Royal Society of Chemistry, Cambridge UK, ISBN: 978-1-84755-895-4, 978-1-78262-626-8, 2008.
3. Introduction to Nanotechnology - R. Singh, S. M. Gupta, Oxford University Press, ISBN:9780199456789, 2016.
4. Nanocomposite Science and Technology, P.M. Ajayan, L.S. Schadler, P.V. Braun, Wiley, New York, ISBN: 9783527303595, 9783527602124, 2003.

5. Block Co-polymers in Nanoscience – Massimo Lazzari, Guojun Liu, Sebastien Lecommandoux, Wiley-VCH Verlag GmbH & Co. KGaA, ISBN: 9783527313099, 2007.
6. The search for novel, superhard materials (Review Article), Stan Vepřek, J. Vac. Sci. Technol. A 17(5), 2401-2420, 1999.

Course Expected Outcomes:

CEO_1	The students will learn the chemical methods of nanoparticle synthesis which help them to apply these techniques while carrying out a reaction in a laboratory/industry.
CEO_2	The students will able to understand types, preparation and applications of Nanocomposites, which is very important for their usage modification if needed to get desired product properties.
CEO_3	The students will understand the preparation, characterization and applications of Nanopolymers, which is helpful in their usage and modification if needed to get desired product properties.
CEO_4	The students will learn about the metal nanoparticles, their characterization and application, which are very important for their role as catalysts.

Nanodevices & Nanosensors

Course Code : NST 106 L- 04 Credits– 04

Course Objectives:

CO_1	To provide students understanding of electron transport in nanoscale and the principles of operation of various nanodevices.
CO_2	To enable students understand the basics of MEMS and NEMS in different applications.
CO_3	To make the student understand how various nanosensors work.
CO_4	To enable student to understand various nanophotovoltaics.

Course Contents:

Unit I : Electron transport in nanoscale: (12 hours)
Quantum and classical regimes of electron transport, mesoscopic transport, Ballistic transport. Diffusive transport: Boltzman transport equation, electron mobility and diffusion coefficient, Drift-diffusion model. Quantum electron transport; Double barrier Resonant-Tunneling structures: Coherent tunneling and sequential tunneling, Negative differential resistance, single electron tunneling, Coulomb blockade.

Unit II : MEMS and NEMS: (10 hours)
Introduction to MEMS, NEMS and their applications.

Unit III: Nanosensors: (10 hours)
Temperature Sensors, Accelerometer, Pressure Sensors, Gas Sensors, Electrochemical Sensors and Biosensors.

Unit IV: Nanostructure based Solar Cells: (12 hours)
Types of Solar Cells: Dye Sensitized, Quantum Dot-based, Perovskite-based and Organic Solar Cells.

Suggested Readings and References

1. Quantum Transport: Atom to Transistor - Supriyo Datta, Cambridge University Press, 2005.
2. Enabling Technology for MEMS and Nanodevices - Balles, Brand, Fedder, Hierold. Wiley, 2014.
3. Nano Engineering in Science & Technology: An introduction to the world of nanodesign-Michael Rieth, World Scientific, 2003.
4. Advanced Materials and Technologies for Micro/Nano-Devices, ,Sensors and Actuators-Evgeni Gusev and Eric Garfunkel (Editors), Springer, 2010.
5. Sensors, Actuators, and their Interfaces: A Multidisciplinary Introduction - Nathan Ida, Institution of Engineering and Technology, 2014
6. Nanotechnology for photovoltaics- Loucas Tsakalakos, 1st Edition, Tailor and Francis, 2010.

Course Expected Outcomes:

CEO_1	The students will be able to understand the basics of electron transport in nanostructures, the theory and working of various nanodevices for applications in nanoelectronics.
CEO_2	The students will be able to understand the basics of MEMS/ NEMS and integration of their components for different applications.
CEO_3	The students will be able to understand the basics of nanosensors and their applications.
CEO_4	The students will be able to understand fundamentals of various aspects of operation, design principles, advantage and disadvantages of nanophotovoltaics.

Solutions & Surface Phenomena

Course Code : NST 108 **L- 04** **Credits– 04**

Course Objectives:

CO_1	This paper provides an understanding of surfactants, micellar chemistry, self-assembly, phase behavior of surfactant systems.
CO_2	It deals with physico-chemical properties of surfactants like wetting, foaming etc..
CO_3	Another crucial objective of this paper is to provide an overview of the concepts of colloids, colloidal forces including electrical double layer and an overview of adsorption.
CO_4	The paper provides knowledge about the process of phase transformation.

Course Contents:

Unit I : Adsorbtions on Solid Surfaces: (10 hours)
Freudlich and Langmuir Adsorption Isotherm. Gibbs Isotherm. Homogeneous and Heterogeneous Catalysis and its fundamental understanding at nanoscale. Role of nanometal and semiconductor particles in industry.

Unit II : Surface Chemistry: (12 hours)
Colloidal state: Interfacial Properties, Origin of Charge on Colloidal Particles, Determination of size of colloidal particles; Types of surfactants: Anionic, cationic, zemini, zwitterionic& non-ionic (non-iogenic); Theory of surfactants; CMC – Effect of chemical structure, temperature; Kraft temperature; Emulsions & gels

Unit III: Phase Behaviour of Concentrated Surfactant Systems: (10 hours)
Micelle type, Micellar growth, Micellar solution saturation; Structure of liquid; crystalline phases; Phase rule, Phase diagram, Binary and ternary phase diagrams of two components & three components, Surfactant geometry & packing; Introduction to microemulsion

Unit IV: Phase Transformations: (12 hours)
Mechanisms of phase transformation; homogeneous and heterogeneous nucleation; spinodal decomposition; grain growth; precipitation in solid solution; transformation with constant composition; order-disorder transformations; Martensitic transformation

Suggested Readings and References

1. Surfactants and Polymers in Aqueous Solution – K. Holmberg, B. Jonsson, B. Kronberg, B. Lindman, Wiley – England, 2004.
2. Dynamics of Surfactant Self – Assemblies – Raoul Zana (Ed.), Taylor & Francis.
3. "Colloidal Dispersion" – Russel W. B, Saville D. A &Schowalter W. R, Cambridge University Press, 1989.
4. Surfaces and Interfacial Phenomena - Milton J. Rosen, Joy T. Kunjappu, 4th Edition John Wiley & Sons, 2012.
5. Introduction to Surface Physics – Martin Prutton, Oxford University Press, 1994.

Approved in the 50th meeting of the academic Council of GGSIP University held on 11/06/2021 vide agenda item AC 50.22

6. Introduction to Thermodynamics of Materials, - Gaskell, David R, 4th edition, Taylor and Francis Publishing 1995.

Course Expected Outcomes:

CEO1	The students will be able to appreciate the developments and advancements in the area of surfactants.
CEO2	They will be able to relate the structure of the surfactant suited for a specific application.
CEO3	They will be able to build strong concepts on colloidal chemistry and adsorption.
CEO4	The students will have adequate knowledge about the important process of phase transformation.

Surface and Supramolecular Chemistry

Course Code : NST 110 **L- 04** **Credits– 04**

Course Objectives:

CO_1	The course aims to cover the importance of adsorption principles.
CO_2	To impart an understanding of different aspects of catalytic processes.
CO_3	The course focuses upon relating the structure and the efficiency of catalytic materials including porous materials.
CO_4	To understand the core concepts of supramolecular chemistry

Course Contents:

Unit I : Adsorption & Catalysis: (10 hours)
Adsorption phenomenon- Chemisorption & Physisorption, adsorption isotherms and methods of determination of pore size and surface area of materials using the adsorption isotherms.
Catalysis - definition, types of catalysis with suitable examples, characteristics of a catalyst, selectivity or specificity of the catalyst, activation and deactivation of catalysts, catalytic poisoning.

Unit II : Important catalytic materials: (12 hours)
Nanostructured metals like Pt, Pd and Fe, nanostructured ceramics like silica, silicate and alumina, pillared clays, colloids and porous materials.

Unit III: Mesoporous materials: (10 hours)
Introduction, synthesis & characterization, properties and applications, unipore size, bimodal pore size, template-based synthesis.

Unit IV: Supramolecular Chemistry: (12 hours)
Introduction to core concepts of supramolecular chemistry: definitions, cooperativity and preorganization, Supramolecular interactions including those in chemomechanical polymers.

Suggested Readings and References

1. Basic Principles in Applied Catalysis - Editor: M. Baerns, Springer Series in Chemical Physics, 2004.
2. Nanoscale Materials - Editors: L. M. Liz-Marzán, P. V. Kamat, Springer, 2004.
3. Nanostructured Catalysts: Nanostructure Science and Technology - Editors: Scott, Susannah L., Cathleen M. Crudden and Christopher W. Jones, Springer, 2003.
4. Concepts of Modern Catalysis and Kinetics - I. Chorkendorff and J. W. Niemantsverdriet, Wiley-VCH Verlag GmbH & Co. KGaA, 2003.
5. The Chemistry of Nanomaterials: Synthesis, Properties and Applications - Editors: C. N. R. Rao, Achim Müller and A. K. Cheetham, Wiley-VCH Verlag GmbH & Co. KGaA, 2004.

Course Expected Outcomes:

CEO_1	The students will have good knowledge about the process of adsorption.
CEO_2	The students will have good knowledge about the process of catalysis.
CEO_3	They will have good knowledge about variety of large number of structures, most suitable for catalytic and sensing applications including porous materials.
CEO_4	The students will have an understanding of basic concepts of supramolecular chemistry.

Human Values and Ethics

Course Code : NST 112 (HVE-102 (Proposed)) L- 02 Credits– 02 NUES

Course Objectives:

CO_1	To develop a universal approach towards human values
CO_2	To be able to strike a balance between aspirations and happiness
CO_3	To understand that humans are a part of nature and how being close to nature bring in joy and satisfaction
CO_4	Select classical short stories from Indian context will expose the students to diverse and multifaceted subsections in Indian society

Course Contents:

Unit I

The Problem and Paradox of Happiness: Twin goals: happiness and just order; role of value education. Concept of good life-quality of life and subjective well-being; happiness, life satisfaction and positive affect; studying quality of life through surveys; and findings of quality of life surveys. Moral and Institutional approaches; and the inherent conflict between the two. Man and Society

(6 Hours)

Unit II

Happiness and Nature: Biophilia hypothesis- connections with nature and co-existence with other forms of life, Deep Ecology, Importance of meaningful contact with the natural world, solutions for a healthier, greener tomorrow, Indigenous and traditional knowledge system and its intellectual roots.

(6 Hours)

Unit III

Basics of Professional Ethics, Ethical Human Conduct: Human Conduct- based on acceptance of basics Human Values, Humanistic Constitution and Universal Human Order-skills, sincerity and fidelity. To identify the scope and characteristics of people-friendly and eco-friendly production systems..

(6 Hours)

Unit IV

Encompassing Different Stories/ narratives on Human Values from Indian Context.

(6 Hours)

Suggested Readings and References

1. Gaur, R.R., Sangal, S.and Bagaria, G., "A Foundation Course in Human Values and Professional Ethics", New Delhi: Excel Books, 2010.
2. Mike, W. Martin, "Paradoxes of Happiness", Journal of Happiness Studies, 2008, pp. 171-184.
3. Giddens, Anthony, "Sociology", 5th edition, Cambridge: Polity Press, 2006.
4. Ambedkar, B.R., Buddha and his dhamma, http://www.scrubd.com/doc/16634512/Buddha-and-His-Dhamma-by-B-R-Ambedkar-Full [accessed on 21 October, 2010]
5. Beteille Andre, "Antinomies of Society: Essays on Ideologies & Institutions", New Delhi: Oxford University Press, 2000.
6. Fikret Berkes, "Sacred Ecology", Second Edition Routledge Taylor & Francis Group, 2008.
7. Richard Louv, "Last Child in the Woods", Algonquin Books, 2008.

Approved in the 50th meeting of the academic Council of GGSIP University held on 11/06/2021 vide agenda item AC 50.22

8. Ramakrishnan, E.V., "Indian Short Stories": (18700-200). Sahitya Akademi, 2012.
9. Davidar, David., "Cluch of Indian Masterpieces", Aleph Book Company, 2016.
10. "Contemporary Indian Short Stories", Sahitya Akademi, 2014.

Course Expected Outcomes:

CEO_1	The students will get sensitized about the role of value education and learn to balance ambition & happiness
CEO_2	The students will be able to understand the importance of living in harmony with nature
CEO_3	The students will be able to see the relevance of Professional behavior and ethics
CEO_4	They will draw inspiration from the classical Indian literature narrated to them in the form of select short stories

Entrepreneurial Mindset

Course Code : NST 114 (USMS112) L- 02 Credits– 02 NUES

Course Objectives:

Course Learning Outcomes: To acquaint students to the world of entrepreneurship and inspire them to set up and manage their business.

Course Contents

Unit I Introduction: The Entrepreneur; Theories of Entrepreneurship; Characteristics of successful entrepreneurs, myths of entrepreneurship; entrepreneurial mindset- creativity and innovation **Role of Entrepreneur:** Factors affecting entrepreneurial growth; Role of Entrepreneurs in Economic Growth

Unit II Promotion of a Venture and Writing a business plan: Opportunity Analysis; External Environment Analysis Economic, Social and Technological Analysis. Business plan- What is business plan, parts of a business plan. Writing a Business Plan

Unit III Entrepreneurship Support: Entrepreneurial Development Programmes (EDP): EDP, Role of Government in Organizing EDPs. Institutions supporting small business enterprises: central level, state level, other agencies, industry associations.

Unit IV Practicals:

- Presenting a business plan
- Project on Startup India or any other government policy on entrepreneurship
- Discussion on why startup fails, role of MSME etc.
- Discussion on role of entrepreneur in economic growth.
- Discussion on technology park.
- Case study discussion on successful Indian entrepreneurs.

Suggested Readings:

1. Charantimath (8th Ed., 2014), Entrepreneurship Development and Small Business Enterprise, Pears Education.
2. Bamford C.E (1st Ed 2015), Entrepreneurship: A Small Business Approach, McGraw Hill Education.
3. Hisrich et al. (2013) Entrepreneurship, McGraw Hill Education
4. Balaraju, Theduri (2012), Entrepreneurship Development: An Analytical Study, Akansha Publishing House.
5. David, Otis, (2014), A Guide to Entrepreneurship, Jaico Books Publishing House, Delhi.
6. Kaulgud, Aruna, (2012), Entrepreneurship Management, Vikas Publishing House, Delhi.
7. Chhabra, T.N. (2014), Entrepreneurship Development, Sun India.

Laboratory-III

Course Code : NST 152 **P- 6** **Credits– 03**

Course Objectives:

CO_1	The objective of this course is to have some experiments based on the applications of surface/interface phenomena.
CO_2	The experiments designed are such that the students are able to apply the already learnt concepts towards developing processes leading to soft synthesis of nanomaterials in a more controlled way.
CO_3	The students will study the impact of size on various physical and chemical properties of nanomaterials by real time hands on practical.
CO_4	They also learn detailed writing, data analysis and discussion of results.

Course Contents:

List of experiments (will be updated from time to time) from which selected experiments will be performed:

1. To investigate adsorption of oxalic acid from aqueous solution by activated charcoal and examine the validity of Freundlich and Langmuir adsorption isotherm.
2. Determination of critical micelle concentration of ionic surfactant (Sodium Dodecyl Suphate) in water by conductivity method. (Determine cell constant using 0.01M KCl solution).
3. Determination of mutual solubility curve of phenol & water, and hence the consulate point/critical solution temperature (CST). To study the effect of presence of salt to the above system.
4. Preparation of water-in-oil micro emulsion and measurement of droplet sizes by Dynamic Light Scattering (DLS).
5. Study the effect of salt & valency of adsorbing ions on particle dispersion stability.
6. Preparation of quantum dots (ZnS) nanoparticles using water-in-oil microemulsion and to estimate the band gap by band gap edge method using UV-Vis spectroscopy.
7. To prepare cholesteric liquid crystals and study the relationship between transition temperature and composition.

Course Expected Outcomes:

CEO_1	The students will learn the fundamental concepts of surface/interface phenomena.
CEO_2	The students will develop fairly good skills towards soft synthetic routes.
CEO_3	They will be able to correlate various process parameters with the physical properties of nanomaterials.
CEO_4	Calculation and interpretation of some fundamental physical parameters such as bandgap, particle size determination, identification of hydrodynamic radius, fingerprinting with optical measurements and DLS will be learnt by the students.

Laboratory-IV

Course Code : NST 154 **P- 6** **Credits– 03**

Course Objectives:

CO_1	The objective of this lab is to take the students to next level of understanding towards fabrication of nanomaterials.
CO_2	The students will explore a close correlation between the physical properties and applications of nanomaterials.
CO_3	The experiments designed are advanced and the students are exposed to RF/DC magnetron sputtering, thermal evaporation, AFM, Raman Spectroscopy and electrical measurements.
CO_4	This lab course aims to blend the concepts learnt by the students in their theory & lab and takes them towards designing hybrid fabrication techniques for developing nanomaterial-based devices.

Course Contents:

List of experiments (will be updated from time to time) from which selected experiments will be performed:

1. Synthesize copper oxide nanoparticles by precipitation method and characterize using atomic force microscopy and Raman spectroscopy.
2. Synthesize nickel oxide nanoparticles by sol-gel method and characterize using Raman spectroscopy.
3. Study the effect of capping on surface plasmon resonance of Ag nanoparticles using UV-visible absorption spectroscopy.
4. Preparation and characterization of nanostructured copper oxide thin films by RF/DC magnetron sputtering.
5. Preparation and characterization of nanostructured TiO_2 thin films by RF magnetron sputtering.
6. Preparation of Ag thin films by thermal evaporation and study annealing induced changes using atomic force microscopy and UV-visible absorption spectroscopy.
8. Synthesis and characterization of Li doped NiO nanoparticles.
9. Preparation and characterization of ferrofluids.
10. Preparation of photochromatic polymer based film and study of exposure based optical property change.
11. Preparation and electrical characterization Ag based single electron tunnelling device in a template based electrochemical synthesis.
12. Treatment of silicon wafer, glass slide, mica surfaces for hydrophobic and hydrophilic nature and study of contact angle of micro water droplet.
13. Preparation and characterization of transparent conducting film.

Course Expected Outcomes:

CEO_1	Students will start learning building blocks of nanotechnology and start thinking about control of size, shape, assembly and their control. Using simple ideas from Physics and Chemistry, they will see how to generate application oriented nanostructures.
CEO_2	Calculation and interpretation of some fundamental physical parameters such as bandgap, particle size determination, identification of hydrodynamic radius, fingerprinting with UV-Vis, Raman spectroscopy, XRD will be learnt by the students.
CEO_3	Basic introduction to electrical properties and their usage will arm them for minor & major projects in manipulating nanomaterials suited for a particular application.
CEO_4	The students will be able to blend the concepts learnt in their theory & lab and move towards designing hybrid fabrication techniques for developing nanomaterial-based devices.

Self-Study-II

Course Code : NST 156 **T- 02** **Credits– 02**

Course Objectives:

CO_1	This is a step forward from Self-Study I.
CO_2	Students are expected to prepare presentations after a more rigorous and diligent literature survey under the close guidance of the NST faculty.
CO_3	Students are expected to assimilate and keep presenting their updated continuous study to the faculties and peers throughout the semester.
CO_4	This will enable them to understand the topic thoroughly and help them prepare strong and quality presentations with adequate defence skills.

Course Contents:

Presentations will be made by the students on emerging topics assigned and supervised by the faculty. The presentations will be subjected to internal and external evaluations.

Course Expected Outcomes:

CEO_1	The presentation skill of the students will be sharpened to professional level.
CEO_2	The students will be able to assimilate the concepts through continuous study and discussions with the faculties throughout the semester.
CEO_3	The students will be able to understand the topic thoroughly and prepare strong and quality presentations with adequate defence skills.
CEO_4	The students from different backgrounds will evolve as proper Nanoscience and Technology students and develop taste and inclination towards specific lines of research/industrial applications.

Carbon Nanostructures

Course Code : NST 201 **L- 04** **Credits– 04**

Course Objectives:

CO_1	To provide students understanding of the structure, synthesis and applications of carbon nanostructures.
CO_2	To enable the students to understand the electronic, mechanical, vibrational and optical properties of carbon nanostructures.
CO_3	This will enable the students understand the different applications of carbon nanostructures.
CO_4	To provide students understanding of functionalization of carbon nanostructures required for different applications.

Course Contents:

Unit I : Synthesis of Carbon Nanostructures: (14 hours)
Introduction to Carbon Nanostructures: Fullerenes, Graphene, Carbon Nanotubes (CNT) and nanodiamonds, Synthesis of Carbon Nanostructures by Arc discharge: CNT, Fullerene; Chemical Vapor Deposition: CNT, Graphene; Pulsed Laser Ablation: CNT; Mechanical-chemical-thermal exfoliation: Graphene.

Unit II : Properties of Carbon Nanostructures: (10 hours)
Properties of Carbon Nanostructures: Electrical, Optical, Mechanical, Vibrational properties

Unit III: Applications of Carbon Nanostructures: (9 hours)
Applications of Carbon Nanostructures: Field emission, Fuel Cells, Display devices, Biosensing.

Unit IV: Functionalization of Carbon Nanostructures: (11 hours)
Reactivity of Carbon Nanostructures, Functionalization of Graphene and Fullerenes,
Covalent Functionalization of Carbon Nanotubes: Oxidative Purification, Defect Functionalization –Transformation and Modification of Carboxylic Functionalization like Amidation, Thiolation, Halogenations, Hydrogenation, Addition of Radicals, Addition of Nucleophilic Carbenes, Sidewall Functionalization through Electrophilic Addition, Cycloadditions, Carbenes Addition, Addition of Nitrenes, Noncovalent Functionalization, Exohedral Functionalization, Endohedral Functionalization

Suggested Readings and References

1. Carbon Nanotubes: Properties and Applications - Michael J. O'Connell, 1st Edition, CRC Press, 2018.
2. Carbon Nanotechnology - Liming Dai (Editor), 1st Edition, Elsevier Science, 2006.
3. Nanotubes and Nanowires - C. N. R. Rao and A. Govindaraj, RCS Publishing, 2005.
4. Nanoscale materials – Luis M. Liz-Marzan, and Prashant V. Kamat, Springer, 2003.
5. Physical properties of Carbon Nanotubes - R. Satio, G. Dresselhaus, M. S. Dresselhaus, Imperial College Press, 1998.
6. Applied Physics of Carbon Nanotubes: Fundamentals of Theory, Optics And Transport Devices - S.V. Rotkin and S. Subramony (Editors), Springer, 2005.

Course Expected Outcomes:

CEO_1	The students will be able to understand the structure and different fabrication techniques used for preparing carbon nanostructures.
CEO_2	The students will be able to understand the different properties of carbon nanostructures.
CEO_3	The students will develop understanding for selecting carbon nanostructures suitable for different applications.
CEO_4	The students will be able to understand the aspects of functionalization of carbon nanostructures necessary for different applications.

Nanomagnetism

Course Code : NST 203 **L- 04** **Credits–04**

Course Objectives:

CO_1	To learn fundamentals of magnetism.
CO_2	To understand the effect of nanoscale on magnetism and its various applications.
CO_3	To acquire knowledge about various instruments used to study nanoscale magnetism, data collection & interpretation.
CO_4	Learning about a relatively important, established and emerging problem in nanoscale magnetism, the debate related to the topic, various strategies and current status.

Course Contents:

Unit I : Introduction: Fundamentals of Magnetism: (10 hours)
Diamagnetism: Theory of Diamagnetism.
Para magnetism: Classical & Quantum Theory of Paramagnetism, Paramagnetic Substances.
Ferromagnetism: Molecular Field Theory, Exchange Forces, Band Theory.
Domain Walls: Domain Wall Structure & observation, Ne´el Walls, Magnetostatic Energy and Domain Structure,
Uniaxial Crystals, Cubic Crystals, Single-Domain Particles, Shapes of Hysteresis Loops.
Antiferromagnetism: Molecular Field Theory, Above T_N, Below T_N, Experiments.
Ferrimagnetism: Structure of Cubic Ferrites, Saturation Magnetization, Hexagonal Ferrites, Other Ferrimagnetic Substances.
Interactions in Magnetic Materials: Exchange Interaction, Magnetostatic Energy, Magnetic Anisotropy, Magnetoelastic Energy and Magnetostriction, Magnetoresistance.

Unit-II: Principles of Nanomagnetism: (12 hours)
Origin of Nanomagnetic Behavior: Sample Dimensions and Characteristic Lengths, Broken Translation Symmetry, Nanoscopic Samples and Magnetization Reversal, Dimensionality and Critical Behavior, Superparamagnetism in metal and semiconductor systems. Surface magnetism. Magnetic Quantum Dots. Various Applications.
Spintronics: Introduction to spin relaxation and spin transport in metal and semiconductors, Magnetic tunnel junction devices. Datta Das Spin Valve and transistor, Metal based switches and valves. Creation of spin polarization through optical or magnetic injection (semiconductor devices), Spin polarized Transport through semiconductor/superconductor interfaces, Spin relaxation in metals and semiconductors.
Magnetoresistance and its growth: The Stoner–Wohlfarth Model, Various Magnetization Reversal, Interaction between Particles.
Magnetism of Thin Films and Multilayers, Anisotropy in Thin Films, Domain Walls and Magnetization Reversal.
Introduction to Magnetotransport, Spin Dependent Scattering and Giant Magnetoresistance, Tunnel Magnetoresistance, Colossal Magnetoresistance and its limitations. Magnetism in Nanodisks, Nanorings and Nanowires.

Spin Glass: Magnetic behavior, Edwards-Anderson model, Sherrington-Kirkpatrick model, Infinite-range model, Non-ergodic behavior & applications, Self-induced spin glass.

Unit III: Experimental measurements: (12 hours)
VSM & SQUID: Operating principle, instrumentation, data visualization. MFM: Operating principle, specialized tips, Contrast Mechanism, Data extraction and interpretation. Magneto-optic Kerr effect (MOKE), Surface magneto-optic Kerr effect (SMOKE), Applications: Microscopy, Magnetic Media. Mössbauer Spectroscopy: Basic principle, Suitable source, Analysis of Mössbauer spectra: Isomer shift, Quadrupole splitting, Magnetic hyperfine splitting, Applications.

Unit IV: Famous debate and New Horizon: (10 hours)
Dilute Magnetic Semiconductor: Magnetic Semiconductor, Advantages of DMS over magnetic semiconductors, examples. Big debate: Is Zinc Oxide a DMS? Doped compound magnetic semiconductors, The Current status of research. The Way forward.
Magnetism in Graphene?: Role played by edges, functional groups, doping & defects. Twisted graphene: Role of various factors. Consequences: magnetism in graphene and its analogues.

Suggested Readings and References

1. Novel Nanocrystalline Alloys and Magnetic Nanomaterials - Editor: Brian Cantor, IOP Publishing, 2004.
2. Physics of Magnetism - S. Chikazumi and S. H. Charap, John Wiley & Sons, 1964.
3. Physical Theory of Ferromagnetic Domains, C. Kittel, Reviews of Modern Physics, vol. 21, issue.4, pp.541-583, 1949.
4. Introduction to Magnetic Materials - B. D. Cullity and C. D. Graham, 2nd Edition, John Wiley & Sons, 2008.
5. Principles of Nanomagnetism - Alberto P. Guimaraes, Springer; Part of the NanoScience and Technology book series.
6. Nanomagnetism and Spintronics – Editor: Teruya Shinjo, 1st Edition, Elsevier, 2009.

Course Expected Outcomes:

CEO_1	To understand the basic magnetism.
CEO_2	To learn about the various types nanomagnetic materials, their special properties such as superparamagnetism.
CEO_3	To understand various modern techniques used in nanomagnetism, with special emphasis on data acquisition, calculation and interpretation.
CEO_4	To discuss two aspects of famous problems. Famous problems are not always fully solved, but they are challenging, therefore would be exposing the students to various aspects of looking at a live problem.

Computational Nanoscience

Course Code : NST 205 **L- 04** **Credits– 04**

Course Objectives:

CO_1	To expose students to solve select problems on Density Functional Theory
CO_2	To reveal students to solve select problems on Molecular Dynamics
CO_3	To educate students to solve select problems on Monte Carlo Simulations
CO_4	To train students to simulate ano materials and nano devices using Mutliscale modeling

Course Contents:

Unit – I: Density Functional Theory (12 hours)
Quantum theory of many electron systems - Hartree and Hartree Fock methods. Beyond Hartree Fock: Wavefunction expansion and perturbation methods. Hohenberg-Kohn theorems, Degenerate ground state, Kohn-Sham equations- Local density approximation. Understanding chemical bonding by DFT.

Unit –II: Molecular Dynamics (12 hours)
Euler, Verlet and Velocity-Verlet integrators for Newtons equations for MD, Interaction potential including long range interactions, Energy minimization techniques, Constant energy and constant temperature simulations, Free energy calculations, Statistical mechanics and treatment of simulation data, Visualisation of structure and data, Electronic degrees of freedom

Unit III: Monte Carlo Simulation (10 hours)
Monte Carlo Simulation and Algorithms to compute density of states, Kinetic Monte Carlo Simulations: Coarse grained atomic simulations.

Unit –IV: Multiscale Modeling (10 hours)
Finite Difference, Finite Volume and Finite Element methods, FDTD/FEM method to Computational Nanoscience & nanodevices. Multiscale Modeling.
Introduction to related computational softwares like: Gaussian/Gamess, SIESTA, VASP, Virtual NanoLab (VNL) with Atomistix ToolKit applied in Carbon nanotubes and graphene, Nanowires, Bulk and nanoscale semiconductors/devices

Suggested Readings and References

1. R.G. Parr and Q. Yang, Density Functional Theory of Atoms and Molecules, (Oxford Science Publications 1989)
2.,Quantum Chemistry by Ira N. Levine, Pearson Education India; Seventh edition (2016)
3. D.W. Heerman, Computer Simulation Methods, (Springer-Verlag, 1986)
4.M.P. Allen and D.J. Tildesley, Computer simulation of Liquids, (Oxford U. Press, New York, 1989)
5. Z. Xiao Guo (Ed), Multiscale Materials Modeling: Fundamentals and Applications, Woodhead Publishing Ltd. (Cambridge, 2007)
6. Introduction to Computer simulation methods- Gould, Tobochnik et al (Addition weekly-2006)

Course Expected Outcomes:

CEO_1	Students will acquire an understanding of Density Functional Theory
CEO_2	They will develop the understanding of molecular dynamics to solve relevant problems.
CEO_3	Using Monte Carlo simulations students will be able to understand nanoscale phenomena.
CEO_4	Students will acquire knowledge base of Mutliscale modeling to simulate nano materials & nano devices.

Nanofabrication with Ion Beams

Course Code : NST 207 **L - 04** **Credits – 04**

Course Objectives:

CO_1	The students will learn the basics of ion-solid interactions, electronic & nuclear stopping and simulation of range distributions by SRIM/ TRIM.
CO_2	The students will able to understand various ion beam processes associated with ion implantation and ion irradiation of solids.
CO_3	The students will learn ion beam synthesis and ion beam engineering of nanostructures.
CO_4	The students will be learn the basics of ion beam nanopatterning.

Course Contents:

Unit I: Ion-Solid Interactions: (12 hours)
Interaction of an energetic charged particle with a free electron gas, Local density approximation in stopping power theory, Electronic stopping, Nuclear stopping, Coulomb explosion & Thermal spike models, Introduction to simulation of range distributions by Monte-Carlo codes SRIM/ TRIM.

Unit II: Ion Beam Processes: (12 hours)
Introduction to ion implantation, Radiation damage in solids: defect formation by ion implantation & ion irradiation, Sputtering, Phase transformation, ion beam mixing, doping, radiation enhanced diffusion, ion induced epitaxial crystallization.

Unit III: Nanostructuring by Ion Beam: (10 hours)
Synthesis of embedded nanoparticles by ion implantation, ion beam mixing, sputtering; Synthesis of nanostructured materials under dense electronic excitation: nanostructures within ion track and at the surface, electronic sputtering of nanostructures.

Unit IV: Ion Beam Nanopatterning: (10 hours)
Fabrication of nanodot arrays, ripples and nanopores, Focused ion beams, ion beam milling, nanolithography, Focused ion beam microsurgery, Oxidation and metallization by ion induced CVD processes.

Suggested Readings and References

1. Accelerator Based Research in Basic and Applied Sciences - Amit Roy and D. K. Avasthi, Phoenix Publishers, 2002.
2. Swift Heavy Ions for Materials Engineering and Nano structuring - D. K. Avasthi and G. K. Mehta, Springer, 2011.
3. Fundamentals of nanoscale film analysis - T. L. Alford, L. C. Feldman and J. W. Mayer, Springer USA, 2007.
4. Materials Science with ion beam - Harry Bernas, Springer 2010.
5. Handbook of nanostructured materials and nanotechnology - Editor: H. S. Nalwa, Acad. Press, 2000.

Approved in the 50th meeting of the academic Council of GGSIP University held on 11/06/2021 vide agenda item AC 50.22

Course Expected Outcomes:

CEO_1	The students will develop an understanding of ion-solid interactions, and will be able to simulate range distributions by SRIM/ TRIM.
CEO_2	The students will develop an understand basics of ion implantation and processes associated with it and ion irradiation of solids.
CEO_3	The students will develop an understanding of approaches used for ion beam synthesis & ion beam engineering of nanostructures
CEO_4	The students will grasp basics of ion beam nanopatterning.

Photonics & Plasmonics

Course Code : NST 209 **L- 04** **Credits– 04**

Course Objectives:

CO_1	To understand various theoretical aspects of nanophotonics.
CO_2	To gain an insight into various aspects of photonic crystals, their integration with electronics, problems and emerging solutions, and various applications.
CO_3	To develop a knowledge base for near field optics, the devices involved, and various applications.
CO_4	To grasp the various aspects of the theory, materials, fabrication, and application of plasmonics.

Unit I: Physics of Photonics: (10 hours)
Idea of diffraction, the resolving power of an instrument. The Diffraction Limit and breaking through the Diffraction Limit. Maxwell's Equations, Bloch's Theorem, Photonic Band Gap and Localized Defect States, Transmission Spectra, Nonlinear Optics in Linear Photonic Crystals, Guided Modes in Photonic Crystals Slab. Projection Operator, Effective Operator and Effective Interaction, Elementary Excitation Mode and Electronic Polarization, Minimal Coupling and Multipolar Hamiltonians, Transformation from Photon Base to Polariton Base

Unit II: Photonic Crystals: Fundamentals, fabrication and applications: (12 hours)
Fundamentals of photonic crystals: Light in periodic structures: photonic crystals, Light in non-periodic structures, Photonic circuitry, Tunneling of light, Physics of Nonlinear Photonic Crystals: 1-D Quasi Phase Matching, Nonlinear Photonic Crystal Analysis.
Fabrication of Photonic Crystals: Fabrication of Photonic Crystals Structures (1-D, 2-D, 3-D).
Applications of Photonic Crystals: 1-D Photonic Crystals, Couplers, Waveguides, High-Q Cavities, 2-D Photonic Crystals, Photonic Crystal Fibers, Tunable Photonic Crystal Filters, Wavelength Converters.

Unit III : Near Field Optics: (10 hours)
Scanning Near Field Optical Microscopy and its applications, Optical near-fields and effective interactions as a base for nanophotonics, Principles of operations of nanophotonic devices using optical near-fields, Principles of nanofabrication using optical near-fields.
Single molecule spectroscopy, its importance and applications.

Unit IV: Elements of Plasmonics: (12 hours)
Introduction to Plasmonics, merging photonics and electronics at nanoscale dimensions, surface plasmon polaritons and localized surface plasmons, single photon transistor using surface plasmons, nanowire surface plasmons-interaction with matter, single emitter as saturable mirror, photon correlation, and integrated systems. All optical modulation by plasmonic excitation of quantum dots, Channel plasmon-polariton guiding by subwavelength metal grooves.

Suggested Readings and References

1. The Handbook of Photonics - Mool Chand Gupta, John Ballato, 2nd Edition, CRC Press, 2019.
2. Nanophotonics - Paras N. Prasad, 1st Edition, John Wiley & Sons, 2004.

3. Optical Properties of Photonic Crystals - K. Sakoda, 1st Edition, Springer Series in Optical Sciences, 2001.

4. Principles of Nanophotonics - Motoichi Ohtsu, Kiyoshi Kobayashi, Tadashi Kawazoe, Takashi Yatsui, Makoto Naruse, **1**st Edition, CRC Press, 2008.

5. Introduction to Nanophotonics - 1st Edition, Sergey V. Gaponenko, Cambridge University Press, 2010.

6. Nanoplasmonics, From fundamentals to Applications vol 1 & 2- S. Kawata & H. Masuhara, 1st Edition, Elsevier, 2006.

Course Expected Outcomes:

CEO1	The students will understand various theoretical aspects of nanophotonics.
CEO2	The students will develop a comprehensive insight into various aspects of photonic crystals, their integration with electronics, problems and emerging solutions, and various applications.
CEO3	The students will assimilate a knowledge base for linear and nonlinear near field optics, the devices involved, and various applications.
CEO4	The students will understand the various aspects of the theory, materials, fabrication, and application of plasmonics.

Nanomedicine

Course Code : NST 211 **L- 04** **Credits– 04**

Course Objectives:

CO_1	To introduce students with concepts of nanomedicine/theranostic agents with different starategies for various diseased condition
CO_2	To provide knowledge about drug delivery systems for various administration routes
CO_3	To make students aware about different drug targeting strategies
CO_4	To make students understand about nanomaterial based contrast agents for various diagnostic techniques including imaging.

Course Contents:

Unit I: Nanomedicines and Applications: (10 hours)
Basic concepts in the design, specification and desired features of nanomedicine and general process steps involved in their preparation Nanomedicines for various disease conditions: infectious diseases, neurological diseases: (challenges of blood brain barrier), pulmonary disorders, cardiovascular diseases, cancer: nano-chemotherapy, - radiation therapy, -immunotherapy, -nuclear medicine therapy, -photodynamic therapy, - photothermal and RF hyperthermia therapy, - scintillation therapy, gene-therapy: DNA, RNA delivery. Theranostic nanomedicines: Basic concept, multifunctional nanomedicines for theranosis.

Unit II: Drug Delivery Systems: (12 hours)
Different types of Drug Delivery Systems based on the Administration Routes: Oral Drug Delivery, Intravenous Drug Delivery -Factors controlling pharmacokinetics of IV formulations, Concept of opsonization, Transdermal Drug Delivery, Intranasal Drug Delivery, Ocular Drug Delivery

Unit III: Drug Targeting: (14 hours)
Miscellaneous Drug Delivery Strategies for Advanced Drug Delivery: Concept of Drug Targeting; Prodrug and Bioconjugation; Nanoscale Drug Delivery Systems - Advantages of nanodrug delivery – Improvements in pharmacokinetics, bioavailability, biodistribution; Concepts of controlled and sustained drug delivery, How nanoparticles pass barriers; Surface modification of nanoparticulate carriers; Nanocarriers for drug delivery - Lipid based pharmaceutical nanoparticles – Liposomes, Solid Lipid Nanoparticles, Nanostructured Lipid Carriers, Cubosomes and Hexosomes, Polymeric Micelles, DNA- Based Nanomaterials, Dendrimers, Polymeric nanoparticles, Inorganic nanoparticles, Hydrogels for controlled drug delivery;
Active and passive nanocarriers – Concept of targeting, Site Specific Drug delivery utilizing Monoclonal Antibodies, Peptides, Other Biomolecules, Stimuli-Responsive Target Strategies; Biomimetic Self-Assembling Nanoparticles, Nanotechnology Challenges.

Unit IV: Diagnostics Using Nano Systems: (8 hours)
Bringing in nanoscale materials and devices for diagnosis: Application in MRI, CT, NIR, Ultrasound, Nuclear and Optical imaging.

Suggested Readings and References

1. Nanoparticulates as Drug Carriers, Vladimir Torchillin, Imperial College Press, 2006
2. The EPR effect for macromolecular drug delivery to solid tumors: improvement of tumor uptake, lowering of systemic toxicity, and distinct tumor imaging in vivo; Maeda, Hiroshi; Nakamura, Hideaki; Fang, Jun; Advanced Drug Delivery Reviews, 65, 71-79, 2013
3. Macromolecular therapeutics in cancer treatment: the EPR effect and beyond; Maeda, Hiroshi, Journal of Controlled Release,164(2), 138-144, 2012
4. Drug Delivery Systems, Pieter Stroeve and Morteza Mahmoudi, World Scientific Series: From Biomaterials towards Medical Devices, Vol I, 2018.
5. Drug Delivery Systems, Vasant V Ranade, John B. Cannon, Third Edition, CRC Press, 2011
6. Emerging nanotechnologies for diagnostics, drug delivery and medical devices, Kishore Cholkar, Abhirup Mandal, Ashim Mitra, Elsevier, 2017.
7. Understanding Nanomedicine: An Introductory Textbook - Rob Burgess, CRC Press, 2012.
8. Nanotoxicology, Materials, Methodologies, and Assessments, Editors: Durán, Nelson, Guterres, Silvia S., Alves, OswaldoLuiz (Eds.),

Course Expected Outcomes:

CEO_1	Students will have good grasp on desired features required for nanotheranostic agents.
CEO_2	Will enable the students to design nanomaterial-based drug delivery systems for various administration routes.
CEO_3	Students will be able to engineer nanoparticles for active drug targeting alongwith controlled drug delivery.
CEO_4	The course will enable the students to design nanomaterials specific to diagnostic applications.

Nanocomposites

Course Code : NST 213 **L- 04** **Credits– 04**

Course Objectives:

CO_1	To enable students to learn the basic preparation of various types of nanocomposites.
CO_2	To enable students to learn the properties and applications of different nanocomposites.
CO_3	To enable students to understand the design of new kind of nanocomposites.
CO_4	The students will learn about polymer based nanocomposites, their mechanical properties and applications.

Course Contents:

Unit I: Types of Nanocomposites: (11 hours)
Introduction to polymers, ceramics and nanocomposites, Classification based on matrix materials: Ceramic matrix nanocomposites, Metal matrix nanocomposites, Polymer matrix nanocomposites, Different aspects of their preparation techniques.

Unit II: Properties, functionality and Applications of Nanocomposites: (12 hours)
Properties, functionality and applications of ceramic matrix nanocomposites, metal matrix nanocomposites, polymer matrix nanocomposites.

Unit III: Novel Nanocomposites: (11 hours)
Super hard nanocomposites, their designing for improved mechanical properties, Core-Shell structured nanocomposites and their surface-trap passivation, Hybrid nanostructures.

Unit IV: Polymer based nanocomposites: (10 hours)
Preparation and characterization of diblock copolymer based nanocomposites, Polymer-carbon nanostructures based nanocomposites, their mechanical properties and industrial possibilities.

Suggested Readings and References

1. Nanocomposite Science and Technology - P. M. Ajayan, L. S. Schadler, P. V. Braun, Wiley, New York, ISBN: 9783527303595, 9783527602124, 2003.
2. Encyclopedia of Nanoscience and Nanotechnology - Hari Singh Nalwa, American Scientific Publishers, 2004.
3. The search for novel, superhard materials (Review Article), Stan Vepřek, J. Vac. Sci. Technol. A 17(5), 2401-2420, 1999.
4. Multifunctional composite core-shell nanoparticles, Suying Wei, Qiang Wang, Jiahua Zhu, Luyi Sun, Hongfei Lin, Zhanhu Guo, Nanoscale, 3, 4474-4502, 2011.
5. Nanocomposites: Synthesis, Structure, Properties and New Application Opportunities, Pedro Henrique Cury Camargo, Kestur Gundappa Satyanarayana, Fernando Wypych, Materials Research, 12, 1-39, 2009.

6. Block Copolymer Nanocomposites: Perspectives for Tailored Functional Materials (Review Article), M. R. Bockstaller, R. A. Mickiewicz, E. L. Thomas, Adv. Mater., 17, 1331-1349, 2005.

Course Expected Outcomes:

CEO_1	The students will study different aspects of the preparation techniques, properties and functionality of Metal, Ceramic and Polymer matrix nanocomposites
CEO_2	The students will be able to understand the properties, functionality and applications of ceramic matrix nanocomposites, metal matrix nanocomposites, polymer matrix nanocomposites.
CEO_3	The students will be able to understand the design of Super hard nanocomposites, Core-Shell structured nanocomposites and Hybrid nanostructures.
CEO_4	The students will be able to grasp the details of polymer based nanocomposites, their mechanical properties and applications.

Open Elective

Course Code : NST 215 **L- 04** **Credits– 04**

Course Objectives:

CO_1	
CO_2	
CO_3	
CO_4	

Course Contents:

Open Elective courses will be chosen from the Programmes of Study offered in any University School of Studies (USS), which have an appropriate relevance to M.Tech. (NST) programme.

Suggested Readings and References

Course Expected Outcomes:

CEO_1	
CEO_2	
CEO_3	
CEO_4	

Computational Laboratory

Course Code : NST 217 **P- 04** **Credits– 02**

Course Objectives:

CO_1	Introduce the students from diverse backgrounds to the importance of computational techniques and to expand their mathematical skills in areas of numerical methods. Introduce the concepts and theory of various simple problems and algorithms that can be subsequently applied to programming in MATLAB/MATHEMATICA to solve then in the Lab**.**
CO_2	Introduce and train students in computational methods with MATLAB/MATHEMATICAas the programming language
CO_3	Problems are selected from a list which is updated from time to time in tune with the needs of industry/research and topical subjects.
CO_4	Educate students to learn the logic behind solving problems related to real physical examples, simulation, modelling and designing the algorithms and translating them into programmes

Course Contents:

List of programming tasks which will be updated from time to time:
1. Introduction to the Matlab programming language
2. Operations in Matlab: basic mathematical operations with matrices & arrays
3. Plotting with Matlab: line plots, 1-D, 2-D, 3-D, meshgrid, labeling axes, legends, importing and plotting data files in Matlab
4. Simple animations
5. Learning to use if, while, elseif commands
6. Numerical methods for Solving Ordinary Differential Equations (ODEs) - Euler method, RungeKutta method etc.
7. Programming in Matlab to solve 1st order and 2nd order ODEs by Euler and RungeKutta methods
8. Solving ODEs using inbuilt matlab solvers
9. The Newton Raphson method for root finding
10. Programming in Matlab to find roots using Newton Raphson method
11. Using direct matlab solvers for root finding
12. Numerical methods for Integration – Rectangular Method
13. Trapezoidal and Simpson's methods
14. Programming in Matlab for integration using the above methods
16. Curve Fitting
17. Introduction to the Monte Carlo method; Estimating the value of pi by Monte Carlo method
18.Integration using Monte Carlo method– single, double, triple integrals

Suggested Readings and References

1. 'Handbook of Theoretical and Computational Nanotechnology, Eds. Michael Rieth and Wolfram Schommers, 2006.
2. Introductory Computational Physics Kelvin and Godunov (Cambridge).

3. Computational Physics, R.C. Verma, K.C. Sharma & P.K. Ahluwalia.
4. Applied Numerical Methods with MATLAB for Engineers and Scientists. By Steven C. Chapra
5. Getting Started with MATLAB, by RudraPratap

Course Expected Outcomes:

CEO_1	They will achieve working knowledge of Linux operating system. And students will become verse with mathematical skills required for programming.
CEO_2	They will generate working knowledge of MATLAB/ MATHEMAICA.
CEO_3	They will be able to solve some famous but basic physics problems using simulation.
CEO_4	The students are expected to develop the flavour of modelling and simulation.

Minor Project

Course Code : NST 251 **Credits– 05**

Course Objectives:

CO_1	Having trained in basics of synthesis and characterization through laboratories I, II, III & IV and being prepared by self-studies and theoretical course work, the students are ripened enough to start thinking about how to design their own projects in consultation of the faculty.
CO_2	These minor projects are prelude to final semester major project and can be either experimental or theoretical in nature or even a combination of the two. However their nature is basic and objective limited and short.
CO_3	The minor project is carried out in-house. But, in order to expose the student to some rare techniques the faculty may think about collaborative approach with other institutes in the country.
CO_4	This will enable the students to be conversant with various equipments with hands on training while carrying out the project. The students are expected to carry out proper literature survey and learn report writing.

Course Contents:

In Minor project the students become increasingly focused towards their research interests, take one particular problem and carry out experimental/theoretical study during this duration. At the end of the semester the students will submit project report and are evaluated on the basis of their presentation, understanding of the subject and analysis of the results. The project will be examined for internal evaluation followed by an external examination involving a presentation and submission of project report.

Course Expected Outcomes:

CEO_1	The students will learn to think about a complete but short project and its design and execution aspect.
CEO_2	They will become conversant with various instruments with hands on approach. They will learn proper literature survey and report writing.
CEO_3	They will learn to work in a goal oriented way and will develop skills for collaborative research.
CEO_4	They will learn to plan and execute the project in a time-bound manner and present their results in a professional way.

Summer Training (Viva-voce)

Course Code : NST 253 **Credits– 03**

Course Objectives:

CO_1	The overall objective of the Summer Training is to train the students to the real research world by working either in house or in other research institutes / industries / universities.
CO_2	The students should have exposure and hands-on-experience.
CO_3	The students should find themselves in a position to channelize their research interests and be able to develop a clarity on the future objectives that they would like to achieve in the following semesters of the course.
CO_4	This will enable the students to get a close insight into the best practices being followed at premium institutions.

Course Contents:

The students will proceed for Summer Training at the end of second semester for a period of 6-8 weeks. The students will then submit the training report after its completion and make a presentation which will be subjected to internal and external evaluations.

Course Expected Outcomes:

CEO_1	The students should find themselves in a position to channelize their research interests and be able to develop a clarity on the future objectives that they would like to achieve in the following semesters of the course.
CEO_2	The students doing their summer training outside the GGSIPU will get introduced to new mentors, scientists and potential collaborators.
CEO_3	The students will learn disciplined work culture of sophisticated research labs & team spirit.
CEO_4	The students will gain valuable exposure and hands-on-experience.

Major Project / Dissertation

Course Code : NST 202 **Credits– 20**

Course Objectives:

CO_1	The major project is the key attribute of the entire course. The students, in conjunction with the faculty, will design and execute a relevant project, where they are supposed use all the skills they have acquired through theoretical course work, laboratories I, II, III & IV, self-study I & II, summer training and the minor project.
CO_2	The work must represent original thinking process, proper literature survey, relevance to current field of emergence. Preferably, the project can be related to the existing or future research area of the faculty.
CO_3	The students will be continuously evaluated throughout the period through presentations and interactions with the faculties.
CO_4	In-house projects are preferred, but in exceptional cases the coordinator may allow partial or complete execution of the project in other institutes of repute with justification.

Course Contents:

Major Project will be undertaken by students in either experimental or theoretical work. It could be carried out either in house, i.e., involving the University Schools and facilities or in industry/research organizations for a period of 6 months along with the preparation of a dissertation. In both cases an internal supervisor from the USBAS is mandatory and an external collaborating supervisor can be involved if needed. The project will be examined for internal evaluation followed by an external examination involving a presentation and final submission of dissertation. Original work leading to a publication will be encouraged.

Course Expected Outcomes:

CEO_1	The student will learn to design and execute a research work in a time bound manner. Following this process, they will become "Research and Industry Ready".
CEO_2	They will develop special interest with meaningful body of work in the field of Nano Science and Technology, based on their training and background.
CEO_3	They should be able to produce a publishable/ patentable work.
CEO_4	They will be encouraged to present their work in National and International conferences.

Comprehensive Viva Voce

Course Code : NST 204 **Credits– 05 NUES**

Course Objectives:

CO_1	The Comprehensive viva voce is to test whether the students have finally assimilated all the aspects studied.
CO_2	It tests the knowledge gained during the various theoretical and experimental training.
CO_3	More emphasis is laid upon testing the understanding acquired by the students during their summer training, minor &major projects.
CO_4	The students should be able to intertwine several concepts learnt across disciplines during the entire course.

Course Contents:

Comprehensive Viva Voce is an internal and external evaluation via a viva voce covering all aspects of the programme including the major project.

Course Expected Outcomes:

CEO_1	The students will be able to put together various concepts and integrate the knowledge base developed in this programme.
CEO_2	The students will finally understand where they stand in the entire scenario of nanoworld research.
CEO_3	They will be able to analyze their relative strengths and weaknesses.
CEO_4	The students should be able to display high level of conviction as they face the viva with the external examiner.