Learning Outcomes- based Curriculum Framework and syllabus for M. Sc. (Nanoscience) (2021 -2022)

CREDIT STRUCTURE For M.Sc. (Nanoscience)
School of Nanotechnology
[CUG, GANDHINAGAR]
(2021-2022)

Course Code	Course Title	Credits
	M.Sc Semester I (Total Credits - 20)	
NSC 401	Physics of nanomaterials	4
NSC 402	Chemistry of nanomaterials	4
NSC 406	Principles of Biology and Nano Biotechnology	4
NSC 407	Synthesis and Characterisation of Nanomaterials	4
NSC 441	Nano Science Practicals – I	4
	M.Sc Semester II (Total Credits -20)	
NSC 454	Nanostructured Materials and their Application	4
NSC 452	Nanotoxicology and Biosafety	4
	OPTIONALS (total 12 credits from any of the courses givenbelow)	
NSC 453	Advanced Characterisation of nanomaterials - II	4
NSC 471	Mathematics and Computational Science	4
NSC 477	Thin film and Vacuum Technology	4
NSC 491	Nano Science Practicals – II	4
NSC 474	Nanotechnology in agriculture and food processing	4
NSC 478	Basics of Pharmaceutical Sciences	4
NSC 492	Nano Science Practicals – III	4
	M.Sc Semester III (Total Credits -16)	
NSC 562	Nano fabrication and nanotechnologies	4
	OPTIONALS (total 12 credits from any of the courses given below)	
NSC 521	Nanomaterials in energy technology	4
NSC 524	Nano devices and sensors	4
NSC 523	Semiconductor materials and applications	4
NSC 527	Nanocarriers for drug and gene delivery	4
NSC 525	Environmental Nanotechnology	4
NSC 526	Basics of Nanomedicines	4
	M.Sc Semester IV (Total Credits -16)	
NSC 591	Dissertation & Viva	8
NSC 551	Term paper, Project proposal and defence I	4
	OPTIONALS (total 4 credits from any of the courses given below)	
NSC 572	Carbon Nanoscience and its applications	4
NSC 574	Basics of Nanotechnology in Tissue Engineering	4
TOTAL		**72**

Program Outcomes

On completion of M.Sc. (Nanotechnology) program, the students will be able to

PO1	Employ concepts and principles of basic sciences at nanoscale.
PO2	Apply multidisciplinary ideas/concepts for various applications of basic sciences in nanotechnology field.
PO3	Implement the advanced analytical tools in the field of nanoscience and nanotechnology.
PO4	Generate innovative/independent ideas for career in academia and nanotechnology-based industries and may emerge as an entrepreneur.
PO5	Apply knowledge/acquired skills for benefits of mankind, environment, and society at large.

Program Specific Outcomes

On completion of M.Sc. (Nanotechnology) program, the students will be able to

PSO1	Utilization of principles of physics, chemistry, and biology for understanding material's properties at nanoscale.
PSO2	Understanding of advanced techniques for synthesis and design of nanomaterials.
PSO3	Learning of advanced characterization tools for analysis of nanostructured materials.
PSO4	Acquittance of multidisciplinary approaches for various applications of nanostructured materials.
PSO5	Involvement in research activities and implementation of innovative ideas in energy, environment, health and agriculture.

SEMESTER I

NSC 401 Physics of Nanomaterials- (4 Credits)

Pre-requisites for the Course: Basic understanding of Physics		
Course Objective: Introduction to Physics of Nanomaterials		
Course outcome: On completion of the course, the students will be able to		
Unit-I	LO1	Understand dual nature of radiation and matter
Unit-II	LO2	Learn atomic structure and Schrodinger equation
Unit-III	LO3	Learn Schrodinger approach for the hydrogen atom and introduction to quantum numbers
Unit-IV	LO4	Learn molecular physics and formation of bonds.

COURSE CONTENT

Unit I

Particle properties of waves: Black body radiation, Photoelectric effect, Compton Effect; Wave properties of particles: De Broglie waves, Wave description, Particle diffraction, Uncertainty principle and application of uncertainty principle.

Unit II

Atomic structure: Electron orbits, The Bohr atom; Quantum Structure: 2D (Quantum well), 1D (Quantum Wires), 0D (Quantum Dots); Quantum mechanics: Schrodinger equation (steady state form), Particle in a box, Finite potential well; Barrier Penetration: Step Potential, Rectangular Barrier Penetration, Applications of Barrier Penetration. Tunnelling: Scanning Tunnelling Microscope; Harmonic Oscillator.

Unit III

Schrodinger approach for the hydrogen atom; Quantum numbers: principal, orbital and magnetic; Electron probability density; Radiative transitions; Selection rules; Normal Zeeman effect; Degeneracy of Hydrogen atom energy levels; Spin Orbit coupling

Unit IV

Molecular Physics: molecular bond, mechanism of covalent bond, H_2^+ molecular Ion, The Hydrogen molecule; Molecular Spectra: Rotational, Vibration Levels and Electronic; Raman Spectrum; Size dependent physical, chemical, optical and magnetic properties.

Text/References

1. Concepts of Modern Physics by Arthur Beiser, TMH Publications.
2. Introductory Nanoscience by Masaru Kuno, Garland Science Publications.
3. Introduction to Solid State Physics by Charles Kittel, Wiley Publications.
4. Handbook of Nanotechnology by Bharatbhushan, Springer Publications, 2010.

NSC 402 Chemistry of Nanomaterials (4 Credits)

Pre-requisites for the Course: Basic knowledge of chemistry
Course Objective: To provide the knowledge and understanding of chemistry of nanomaterials in term

of chemical synthesis methods of nanomaterials, morphology, characterization and different chemical properties of nanomaterials.		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Know about the nomenclature of nanomaterials and how properties changes in nanomaterials (metals, alloys and semiconductors) as compare to their bulk counterpart. Students will also acquire knowledge about carbon nanomaterials their properties. They will also understand the quantum confinement and basics about device fabrications.
Unit-II	LO2	Learn how nanomaterials will grow by bottom up methods and self assembled in beautiful morphologies. They can co relates the nanoscale phenomenon by quantum mechanics with example of particle in one dimension box. They will also understand about the basics of kinetics/thermodynamics of nanomaterials and stability of colloidal sols and how zeta potential will help in it.
Unit-III	LO3	Learn about solid state chemistry and how crystal structures will change in nanomaterials. This understanding will be helpful in XRD data analysis if They registered for PhD program.
Unit-IV	LO4	Understand the novel properties like optical, electronic, photonic, magnetic and catalytic. This will helpful for students in advanced level research further.

COURSE CONTENT

Unit I

Classification and nomenclature of nanomaterials: Nanosized metals and alloys, semiconductors, ceramics–a comparison with respective bulk materials, Organic semiconductors, carbon materials, quantum dots, quantum wells, quantum rods, quantum wires, quantum rings; bulk nanostructured, nanocomposites, nanomachines and Devices.

Unit II

Characteristics of Nanomaterials: Nucleation and growth of nanosystems, self-assembly, functional nanomaterials and nanostructured thin films. Quantum confinement in semiconductors – particle in a box like model for quantum dots, origin of charge on colloidal sols, zeta potential, basics of thermodynamics and kinetics related to nanoparticles

Unit III

Structure and Morphology of Nanoparticles: Crystal structure of materials, packing fraction, basics of solid-state chemistry, specific surface energy and surface stress and effect on the lattice parameter. Nanoparticle morphology and morphology of supported particles.

Unit IV

Novel Properties of Nanomaterials: Size and shape dependent optical, emission, electronic, transport, photonic, refractive index, dielectric, mechanical, magnetic, non-linear optical properties; transition metal sols, origin of plasmon band, Mie theory, influence of various factors on the plasmon absorption, catalytic properties.

Text/References

1. Klabunde, K.J. (Ed.), "Nanoscale Materials in Chemistry", John Wiley & Sons Inc. 2001
2. Nalwa, H.S. (Ed.), "Encyclopedia of Nanoscience and Nanotechnology" 2004
3. Sergeev, G.B. Nanochemistry, Elsevier, B.V. 2010
4. Schmid, G. (Ed.), "Nanoparticles", Wiley-VCH Verlag GmbH & Co. KgaA.2004
5. Rao, C.N.R., Müller, A. and Cheentham, A.K. (Eds.),"Chemistry of Nanomaterials",

Wiley – VCH. 2005

NSC 406 Principles of Biology and Nano Biotechnology (4 Credits)

Pre-requisites for the Course: Student should have fundamental knowledge of biology		
Course Objective: Introduce basic principles of biology and nanobiotechnology to students		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Learn basics of cellular biology highlighting major function of cell
Unit-II	LO2	Learn the concept of Nano-biomaterials and biocompatibility in terms of cell-material interaction
Unit-III	LO3	Learn Structural & Functional Principles of Bio-nanotechnology
Unit-IV	LO4	Learn application of nanoparticles in biological labelling and bioanalysis

COURSE CONTENT

Unit I

Basics of Cell biology: Basic structure of mammalian cell membrane, Cell Cycle, Different types of Cell receptors, Cell lines-Cancerous and Normal cell line, Primary and secondary cell line, Endocytosis and Exocytosis, Reticulo endothelial system (RES), Proteins structure-primary, secondary, tertiary and quaternary structure, Enzymes structure w.r.t metal part, prosthetic group (Metalloenzymes). Antigen-Antibody based assays-Elisa.

Unit II

Nanobiomaterials And Biocompatibility: Surface and Bulk Properties of Bio materials – Nanobiomaterials –NanoCeramics – Nanopolymers – Nano Silica – Hydroxy apatite – Carbon Based nanomaterials, Surface modification – Textured and Porous Materials – Surface immobilized biomolecules – Cell-biomaterial interactions – immune response – In Vitro and In Vivo assessment of tissue compatibility.

Unit III

Structural & Functional Principles Of Bio-nanotechnology: Lipid Bilayers – Liposomes – Neosomes-Phytosomes, Polysacharides – Peptides –Nucleic acids – DNA scaffolds –Enzymes- Biomolecular motors, Immunotoxins – Membrane transporters and pumps – Antibodies – monoclonal Antibodies – immunoconjugates – limitations of natural biomolecules

Unit IV

Nanobio-Analytics: Luminescent Quantum Dots for Biological Labeling – Nanoparticle Molecular Labels – Surface Biology: Analysis of Biomolecular Structure by Atomic Force Microscopy and Molecular Pulling – Force Spectroscopy – Biofunctionalized Nanoparticles for Surface – Enhanced Raman Scattering and Surface Plasmon Resonance – Bioconjugated Silica Nanoparticles for Bioanalytical Applications

Text/References

1) Nanobiotechnology: Concepts, Applications and Perspectives by Niemeyer C. M., Wiley – VCH, 2006. 2) Bionanotechnology by David S Goodsell, John Wiley & Sons, 2004. 3) Bio-Nanotechnology: A Revolution in Food, Biomedical and Health Sciences by Debasis Bagchi, Manashi Bagchi, Hiroyoshi Moriyama, Fereidoon Shahidi, Wiley-Blackwell, 2013. 4) Biomaterials Science: An Introduction to Materials in Medicine by Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen , Jack E. Lemons, Academic Press, 2012.

NSC 407 Synthesis and Characterization of Nanomaterials (4 Credits)

Pre-requisites for the Course: Basic knowledge of physic and chemistry		
Course Objective: To provide the detail knowledge about the top down and bottom up synthesis of nanomaterials and their characterization through advanced analytical techniques.		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Differentiate the nanomaterials according to their confinements in 1-D, 2-D and 3-D. They will also learn the different top down and bottom-up approaches of nanomaterials synthesis.
Unit-II	LO2	Learn the synthesis of nanomaterials by sol-gel method, hydrothermal, micro emulsion technique, chemical reduction, decomposition of organometallic precursors and chemical vapor deposition. They will also familiar with low temperature cyrochemical synthesis.
Unit-III	LO3	Understand ball milling, sputtering, microwave plasma and photolysis processes. They will also learn the role of surfactants in formation of self-assembled nanostructures. They will also learn the various parameters required to good quality thin film deposition with quantum dots and nanowires morphology. Students will be familiar with how to make single walled and multi walled carbon nano tubes.
Unit-IV	LO4	Learn the working and principles of various analytical tools such as XRD, UV-VIS spectroscopy, Raman spectroscopy and XPS required for the characterization of nanomaterials. They will be able to interpret and analyse the data.
COURSE CONTENT		
Unit I Classifications and types of nanomaterials as nano particles and 1D 2D 3D nanomaterials. Concept of bulk versus nanomaterials and dependence of properties on size. Introduction to 'Top down' vs. 'Bottom up' approach of synthesis with suitable examples.		
Unit II Nano synthesis techniques based on liquid and vapor phase as the starting material. The study of wet chemical method like sol-gel method, hydrothermal, micro emulsion technique, chemical reduction, decomposition of organometallic precursors and chemical vapor deposition, metallo-organic chemical vapor deposition. Cryochemical synthesis, study of rapid solidification route, electro and electroless deposition etc. along with suitable examples		
Unit III Mechanical milling, laser ablation, microwave and ultrasound assisted synthesis sputtering and microwave plasma, photolysis, radiolysis, surfactant behavior, micelles, self-assembled mono layers (SAM's), Langmuir-Blodget (LB) films. Designing of advanced integrated nanocomposites, preparation of quantum dots, nano wires and films, preparation of single-walled and multi-walled nanotubes.		
Unit IV Techniques of characterization of size of nano powders/ particles using BET method and laser diffraction. Various spectroscopic techniques like optical spectroscopy. UV visible and Infrared spectroscopy. Raman spectroscopy. X-ray photoelectron spectroscopy. Basic understanding of each technique with special emphasis on characterization at nano scale. X-ray Fluorescence (XRF), X-ray diffraction (XRD) and Small Angle X-ray Scattering principles.		
Text/References 1. Nanomaterials Chemistry by Rao C. N., A. Muller, A. K. Cheetham,, WileyVCH , 2007.		

2. Nanomaterials and Nanochemistry by Brechignac C., P. Houdy, M. Lahmani, Springer publication, 2007.
3. Nanoscale materials in chemistry by Kenneth J. Klabunde, Wiley Interscience Publications,2001.
4. Nanochemistry by Sergeev G.B., Elseiver publication,2006.
5. Nanostructures and Nanomaterials, synthesis, properties and applications by Guozhong Cao, Imperial College Press, 2004.
6. Nanomaterials – Handbook by Yury Gogotsi, CRC Press, Taylor & Francis group, 2006.

NSC 441 Nano Science Practical-I (4 Credits)

Pre-requisites for the Course: Basic understanding of chemistry and materials

Course Objective: To impart detailed knowledge about synthesis of nanomaterials by different approaches and their characterization through advanced analytical techniques.

Course Outcome: On completion of the course, the students will be able to Synthesize nanomaterials by hydrothermal, reduction-based method and chemical vapor deposition. They will also get familiar with characterization tools like UV-Vis spectroscopy and FTIR spectroscopy.

COURSE CONTENT

List of experiments

1. Synthesis of Au/Ag metal nanoparticles by chemical route.
2. Optical properties of Au/Ag nanoparticles by using UV-Vis spectroscopy.
3. Synthesis of transition metal oxide nanoparticles by hydrothermal route.
4. To calculate the absorption coefficient and optical band gap using UV-Vis. Spectroscopy.
5. Synthesis of CNTs BY CVD method.
6. Analysis of CNTs by UV-Vis. and FTIR spectroscopy.
7. Synthesis of CNT nanocomposites.
8. Analysis of CNT nanocomposites by UV-Vis. and FTIR spectroscopy.

Text/References

1. Nanomaterials Chemistry by Rao C. N., A. Muller, A. K. Cheetham,, WileyVCH , 2007.
2. Nanomaterials and Nanochemistry by Brechignac C., P. Houdy, M. Lahmani, Springer publication, 2007.
3. Nanoscale materials in chemistry by Kenneth J. Klabunde, Wiley Interscience Publications,2001.
4. Nanochemistry by Sergeev G.B., Elseiver publication,2006.
5. Nanostructures and Nanomaterials, synthesis, properties and applications by Guozhong Cao, Imperial College Press, 2004.
6. Nanomaterials – Handbook by Yury Gogotsi, CRC Press, Taylor & Francis group, 2006. NSC

SEMESTER II

NSC 454 Nanostructured materials and applications (4 Credits)

Pre-requisites for the Course: Basic knowledge of nanoscience and nanomaterials		
Course Objectives: To study about the synthesis of composite nanomaterials. To study the different properties of ceramic nanomaterials. To study advance miscellaneous applications of nanotechnology.		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Understand the synthesis of the metal-metal nanocomposites. They will also acquire the deep knowledge about the nuclear energy applications of metal-metal composites. They will also get overview about magnetic nanocomposites and use of these nanocomposites in spintronics applications. They will also learn about high temperature applications of nanocomposites.
Unit-II	LO2	Learn about the definition of ceramic and how ceramics are different from other nanomaterials. They will also familiar with the basics of dielectrics, ferroelectrics and diblock copolymers which are very important for memory devices. They will also learn the role of nanopolymers in catalysts.
Unit-III	LO3	Know about the different conducting polymers which are very crucial for the different applications nowadays. They will also able to synthesized conducting polymers by chemical and electrochemical methods. They will also get clear understanding about of different applications of conducting polymers like corrosion protection, sensors and electrochemical energy devices.
Unit-IV	LO4	Learn about the biological applications nanocomposites, ceramics and polymers. They will be familiar about the dental implantation and other bio based consumer products. They will also learn the tissue engineering and biopolymer tagging.
COURSE CONTENT		
Unit I Nano Composites and their Applications, Metal-Metal nanocomposites for nuclear energy applications, Magnetic nanocomposites for Spintronics application, Ceramic nanocomposites for high temperature applications.		
Unit II Nano ceramics: Dielectrics, ferroelectrics and magneto ceramics, Nanopolymers: Preparation and characterization of diblock Copolymer based nanocomposites, Nanoparticles polymer ensembles; Applications of Nanopolymers in Catalysis.		
Unit III Classification of conducting polymers: Intrinsic and extrinsic conducting polymers - Chemical and electrochemical methods of the synthesis of conducting polymers – Applications ofconducting polymers in corrosion protection, sensors, electronic and electrochemical energy devices.		
Unit IV Miscellaneous applications of nanotechnology: dental implants, consumer products, biomimetic nanomaterials for tissue engineering, biopolymer tagging, semiconductor quantum dots.		
Text/References 1. Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor 2. Nanoscale materials -Liz Marzan and Kamat. 3. Physical properties of Carbon Nanotube-R Satio.		

4. Polymer nanocomposites: Edited by Yiu-Wing Mai and Zhong-Zhen Yu, First published 2006, Woodhead Publishing Limited and CRC Press LLC, USA.
5. Physics of Magnetism - S. Chikazumi and S.H. Charap.
6. Magnetostriction and Magnetomechanical Effects - E.W. Lee.
7. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell.
8. Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor
9. Nanoscale materials -Liz Marzan and Kamat.
10. Physical properties of Carbon Nanotube-R Satio.
11. Polymer nanocomposites: Edited by Yiu-Wing Mai and Zhong-Zhen Yu, First published 2006, Woodhead Publishing Limited and CRC Press LLC, USA.
12. Physics of Magnetism - S. Chikazumi and S.H. Charap.
13. Magnetostriction and Magnetomechanical Effects - E.W. Lee.
14. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell.

NSC 452: Nanotoxicology and Biosafety (4 Credits)

Pre-requisites for the Course: Fundamental knowledge of biology		
Course Objective: Introduce fundamental issues of toxicology and biosafety related to nanomaterials		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Know about different route of entry of NPs in human body and its attribute related to toxicity
Unit-II	LO2	Learn about classification of nanoparticles and their invitro toxicological effects
Unit-III	LO3	Understand about the different mechanisms of nanomaterial toxicity
Unit-IV	LO4	Learn about different assays used for determining cellular toxicity in-vitro and in-vivo.

COURSE CONTENT

Unit I

Introduction, source of nanoparticles, epidemiological evidences, entry routes for nanoparticles in human body: lungs, intestinal tract and skin, Deposition and translocation in the body, Attributes contribute to nanomaterials toxicity.

Unit II

Classification of nanoparticles for biological applications, nanoparticles interaction with the biological membrane, uptake and toxicological effects of different nanoparticles.

Unit III

Mechanisms of nanomaterial toxicity: oxidative stress, ecotoxicity, genotoxicity, hemolytic toxicity, mutagenicity and immunotoxicity.

Unit IV

Assessment of nanomaterial toxicity: In vitro toxicity assessment-cell viability, lactate dehydrogenase release, reactive oxygen species generation, change in mitochondrial membrane potential and nuclear fragmentation. In vivo toxicity assessment: inflammatory response, acute toxicity studies, LD50 determination, histopathological studies.

Text/References

1.Handbook of Nanotoxicology, Nanomedicine and Stem Cell Use in Toxicology. Saura C Sahu, Daniel A Casciano. 2.Nanotoxicology - Interactions of Nanomaterials with Biological Systems. Yuliang Zhao and Hari Singh Nalwa. 3.Biointeractions of Nanomaterials. Vijaykumar B. Sutariya, Yashwant Pathak 4. New Technologies for Toxicity Testing. Michael Balls DPhil, Robert D. Combes PhD, Nirmala Bhogal

NSC 453 Advanced Characterisation of nanomaterials - II (4 Credits)

Pre-requisites for the Course: Understanding of basics of Physics and Chemistry		
Course Objective: Introduction to advanced instrumental techniques for the characterization of nanomaterials		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Understand advanced electron microscopic techniques.
Unit-II	LO2	Understand advanced force microscopic techniques.
Unit-III	LO3	Know magnetic and mechanical characterization of materials.
Unit-IV	LO4	Learn electrical and dielectrical characterization of materials.

COURSE CONTENT

Unit I

Understanding of micro structural developments in nanomaterials using optical microscopy, Scanning Electron Microscopy (STM) and Transmission Electron Microscopy (TEM) approach, High resolution Transmission Electron Microscopy (HRTEM).

Unit II

Advanced Microscopic techniques: Scanning probe microscopy e.g. Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM), Magnetic Force Microscopy (MFM), Chemical Force Microscopy (CFM).

Unit III

Magnetic measurements: Vibrating sample magnetometer (VSM), Electron Paramagnetic Resonance (EPR), Nuclear Magnetic Resonance (NMR) spectroscopy; Mechanical properties: Ultimate Tensile Strength, Micro hardness, nano indentation (elastic and plastic deformation).

Unit IV

Electrical measurements: I-V/C-V characteristics, Hall effects, FET characteristics, R-T measurements, Dielectric measurements.

Text/References

1 The structure and properties of materials by R.M.Rose, L.A.Shepard and J. Wulff, Wiley Eastern Ltd., 1966.

2. Semiconductor Devices – Physics and Technology by S.M. Sze, Wiley, 1985.

3. Semiconductor Material and Device Characterization by D. K. Schroder, John Wiley & Sons,New York, 1998.

4. Encyclopedia of Materials Characterization by C. Richard Brundle Charles A. Evans, Jr.Shaun Wilson ,Butterworth-Heinemann, 1992.

OPTIONALS

NSC 471 Mathematics and Computational Science (4 Credits)

Pre-requisites for the Course: Understanding of basic physics		
Course Objective: Introduction to computers, statistics and computational science		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Understand basics of computers and statistics
Unit-II	LO2	Solve transcendental equations
Unit-III	LO3	Learn Curve-Fitting by different techniques.
Unit-IV	LO4	Learn molecular dynamics
COURSE CONTENT		
Unit I Introduction to computers and statistics. Computer Arithmetic: Floating Point Numbers And Round Off Errors, Absolute And Relative Errors, Polynomial Interpolation: Numerical Integration by Trapezoidal Rule, Simpson's Rule, Error Analysis. Solution Of System Of Linear Equations		
Unit II Solution of Transcendental Equation By Bisection Method And Newton's Method. System Of Non Linear Equations: Newton-Raphson's Method. Finite difference method		
Unit III Curve-Fitting by Least Square Techniques. Numerical Solution Of ODE, Single Step Method Runge Kutta Methods, Numerical Solution To PDE, Stability And Convergence.		
Unit IV Introduction to molecular dynamics, first principle solution, potential determination,Density Functional Theory (DFT)		
Text/References 1. Higher Engineering Mathematics by B. S. Grewal, Khanna Publishers Delhi 2. Introductory Numerical Analysis By S. S. Sastry, Prentice Hall Publishers		

NSC 477 Thin Film and Vacuum Technology (4 Credits)

Pre-requisites for the Course: Understanding of basic Physics		
Course Objective: Introduction to thin film and vacuum technology		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Understand basics of vacuum technology
Unit-II	LO2	Understand thin film growth
Unit-III	LO3	Learn thin film deposition and etching techniques.
Unit-IV	LO4	Learn thin film characterization methods.
COURSE CONTENT		
Unit I Vacuum Technology: Gas Laws, Kinetic Theory of Gases, Conductance and Throughput, Gas Sources in a Vacuum Chamber, Vacuum Pumps.		
Unit II		

Thermodynamics and Thin Film growth, Film Formation and Structure: Capillarity Theory, Atomistic Nucleation processes, Cluster Coalescence, Grain Structure of Films.

Unit III

Physical Vapor Deposition: Sputtering (Plasma Physics (DC Diode), rf Plasmas, Magnetic Fields in Plasmas, Sputtering Mechanisms), Evaporation. Chemical Vapor Deposition: Mechanisms, Materials, Chemistries, Systems. Etching: Wet Chemical Etching (Mechanisms, Materials and Chemistries), Dry Plasma Etching/Reactive Ion Etching (Mechanisms, Materials and Chemistries).

Unit IV

Thin Film Characterization: Structural, Chemical, optical, electrical, magnetic: Structural, Chemical, optical, electrical, magnetic

Text/References

1 Thin Film Deposition and Patterning: R. K. Waits, American Vacuum Society, 1998.
2.The Materials Science of Thin Films: M. Ohring, Academic Press, Boston, 1991
3. Physics of Thin Films: Ludmila Eckertova, 2nd Plenum Press New York, 1986
4. Thin Film Phenomena: K. L. Chopra, McGraw-Hill, 1969

NSC-491 Nano Science Practical-II (4 Credits)

Pre-requisites for the Course: Understanding of basic Physics and Chemistry

Course Objective: Hands on experience on various techniques for synthesis and characterization of nanomaterials.

Course outcome: On completion of the course, the students will get hands on experience on synthesis of polymeric nanoparticles and surfactant based micellular system, and their characterisation using AFM. They will also learn the electrical characterization of bulk and thin film.

COURSE CONTENT

List of experiments

1. Study of chemical kinetics using UV-Vis spectroscopy.
2. Synthesis of quantum dots using chemical route and their emission properties.
3. Grain size measurement by optical microscopy.
4. Synthesis of colloidal solution and demonstration of Tindal effect.
5. Handling of AFM microscopy.
6. To determine the surface roughness of AFM images using offline SPM software.
7. Synthesis of polymeric nanoparticles by solvent evaporation method and characterization.
8. Synthesis and characterization of surfactant based micellular system.
9. I-V characterization of metallic film using four probes.
10. Hall study for Si and Ge samples.

Text/References

1. Edelstein A S and Cammarata R C, "Nanomaterials: Synthesis, Propertiesand Applictions",Taylor and Francis, 2012

NSC 474 Nanotechnology in agriculture and food processing (4 Credits)

Pre-requisites for the Course: Basic understanding of biology		
Course Objective: Learn about various application of nanotechnology for agriculture and food processing		
Course outcome: On completion of the course, the students will be able to understand about the		
Unit-I	LO1	Various aspect of agriculture and types of nanomaterial utilized for it.
Unit-II	LO2	Various diagnostic and sensing mechanism used for agriculture
Unit-III	LO3	Different application of nanotechnology in agriculture
Unit-IV	LO4	Application of Nanotechnology in packaging/increasing nutritional values or shelf life

COURSE CONTENT

Unit I

Introduction: Rhizosphere, Soil health-Different Indicators (Assays) for determining soil health. Surfactants-Biological and Synthetic, Pesticides, Insecticides, Herbicides, Weedicides, Biomagnification, Micro and Macro nutrients required by plants. Various types of nanomaterial utilized in agriculture.

Unit II

Nanoparticles in agricultural and food diagnostics: Enzyme Biosensors and Diagnostics - DNA-Based Biosensors and Diagnostics, Radiofrequency Identification. Lateral Flow (Immuno)assay - Nucleic Acid Lateral Flow (Immuno)assay-Flow-Through (Immuno)assays - Antibody Microarrays.

Unit III

Nanotechnology in food production: Food and new ways of food production -Efficient fractionation of crops, Efficient product structuring -Optimizing Nutritional Values - Applications of Nanotechnology in Foods : Sensing, Engineering Food Ingredients to Improve Bioavailability - Nanocrystalline Food Ingredients – Nano-emulsions – Nanoengineered Protein Fibrils as Ingredient Building Blocks.

Unit IV

Nanotechnology in food packaging: Reasons to Package Food Products. Physical Properties of Packaging Materials - Strength - Barrier Properties, Light Absorption – Structuring of Interior Surfaces - Antimicrobial Functionality - Visual Indicators – Quality Assessment - Food Safety Indication - Product Properties. Smart nanomaterials for packaging.

Text/References

1) Nanoparticle Assemblies and Superstructures by Nicholas A. Kotov, CRC, 2006.
2) Nanotechnology in agriculture and food production by Jennifer Kuzma and Peter VerHage,, Woodrow Wilson International, 2006.
3) Bionanotechnology by David S Goodsell, John Wiley & Sons, 2004.
4) Nanobiomaterials Handbook by Balaji Sitharaman, Taylor & Francis Group, 2011.

NSC 478: Basics of Pharmaceutical Sciences (4 Credits)

Pre-requisites for the Course: Basic understanding of biology		
Course Objective: Introduce fundamental of pharmaceutical sciences and product development		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Know about the various pharmaceutical dosage forms and routes of drug administration
Unit-II	LO2	Understand the sources of drugs, pharmacokinetics and pharmacodynamic processes
Unit-III	LO3	Learn about basics of pharmaceutical product development
Unit-IV	LO4	Learn about the drug degradation and stability aspects of pharmaceutical products

COURSE CONTENT

Unit I

Introduction to pharmaceutical sciences, principles and types of pharmaceutical dosage forms-solid, liquid, semi-solids, aerosols. Routes of drug administration

Unit II

Basics of pharmacology: Overview, sources of drugs, routes of drug administration,
Pharmacokinetics-absorption, distribution, metabolism and excretion,
Pharmacodynamics, Adverse drug reactions, Drug interactions.

Unit III

Pharmaceutical product development: Fundamental aspects, pharmaceutical excipients, biopharmaceutical considerations, Principles of solubilization, dissolution, partition coefficient, ionization and bioavailability.

Unit IV

Kinetics and Drug stability: General concept of physical and chemical stability of pharmaceutical product, factors affecting drug stability, Degradation rate constant, Half-life determination and expiration dating, Introduction to ICH guidelines, Accelerated stability studies.

Text/References

1. Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems. By: Loyd V. Allen,Howard C. Ansel
2. Essentials of Medical Pharmacology, by K.D. Tripathi. Published by Yaypee brothers medical publishers.
3. Rang & Dale's Pharmacology. James M. Ritter, Rod J. Flower, and Graeme Henderson,
4. Martin's Physical Pharmacy and Pharmaceutical Sciences. Lippincott Williams & Wilkins.

NSC 492 Nano Science Practical-III (4 Credits)

Pre-requisites for the Course: Basic understanding of biology and nanoscience
Course Objective: To get hands on experience related to synthesis of polymeric/micellar structure, bioconjugation technique and biological application of these synthesized NPs.
Course outcome: On completion of the course, the students will get hands on experience on Synthesis of different NPs and nanomicelles, bioconjugation/crosslinking techniques, basic techniques used for drug delivery studies and molecular biology e.g gel electrophoresis
COURSE CONTENT
List of experiments: 1. Synthesis of biodegradable micelles and inverse micelles. 2. Synthesis of metal nanoparticles using plant extracts and characterization. 3. Synthesis and characterization of polymeric nanoparticles for drug delivery. 4. Synthesis and characterization of lipid-based nanoparticles for drug delivery. 5. Determination of antimicrobial properties of silver nanoparticles. 6. Functionalization of nanoparticles with proteins. 7. Microwave synthesis of materials for dental implants. 8. Biosensing by nanozymes using UV-Vis spectroscopy 9. Bioconjugation of DNA with metal nanoparticles. 10. To determine the dissolution of hydrophobic drug in physiological solutions. 11. Study of biomolecule crosslinking by electrophoretic method

SEMESTER III

NSC 562: Nano fabrication and nanotechnologies (4 Credits)

Pre-requisites for the Course: Understanding of basic Physics		
Course Objective: Introduction to nano fabrication and nanotechnologies		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Learn nanofabrication processes.
Unit-II	LO2	Learn precision engineering in VLSI technology
Unit-III	LO3	Learn nanofabrication in semiconductor industry
Unit-IV	LO4	Learn nanofabrication rules and steps of CMOS fabrication
COURSE CONTENT		
Unit I Nanofabrication processes: Concept of Top Down and Bottom Up Fabrication approach, Bio-mediated assembly, template assisted synthesis, epitaxial growth.		
Unit II Precision Engineering in VLSI technology: Electron beam lithography (EBL), UV imprint lithography, Nanoimprint lithography, focused ion beam (FIB), pulsed laser ablation, Multilayers structures for device applications, ion beam nano structuring		
Unit III Nanofabrication in semiconductor industry: Metal Oxide Semiconductor (MOS) transistor, NMOS and PMOS transistors, Complementary Metal Oxide Semiconductor (CMOS)		

transistor

Unit IV

Fabrication: Design rules, Clean rooms, Wafer cleaning and Gettering, Oxidation, Photoresist, Photolithography, Etching, Device isolation, N and P well formation, Gate formation, Source/Drain formation, Contact and local interconnect formation (Metallization).

Text/References

1. Silicon VLSI Technology: Fundamentals, Practice, and Modeling 1st Edition by James D. Plummer, Michael Deal, Peter D. Griffin (Pearson Education).
2. Handbook of Nanofabrication: Editor Gary P. Wiederrecht, Elsevier publication.
3. Nanostructures-Fabrication and analysis: Editor: H. Nejo, Springer publication.
4. Principles of Lithography: Harry J. Levinson.

OPTIONAL

NSC 521 Nanomaterials in Energy Technology (4 Credits)

Pre-requisites for the Course: Understanding of basic chemistry

Course Objective: To use the nanotechnology for generation of green and sustainable energy. To be familiar with energy storage devices such as Li-ion batteries and supercapacitors.

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

Unit-I	LO1	Learn the role of nanotechnology for sustainable energy and conversion of energy directly or indirectly. They will also familiar with nanoscale catalysts used to enhance the production rate.
Unit-II	LO2	Learn the various methods for hydrogen production. They will also acquire knowledge about thermal decomposition, photochemical and photocatalysts. They will also learn about the techniques used to hydrogen storage.
Unit-III	LO3	Get quick knowledge about the electrochemical storage devices. They will know the principle of primary, secondary, solid state, lead acid, nickel cadmium and advanced li-ion batteries. They will also know about the LEDs, catalytic reactors and capacitor fuel cells.
Unit-IV	LO4	Get knowledge about the nanomaterials used for data storage devices. They will learn the various parameters that can enhanced the overall storage. They will also learn the role of carbon materials in energy storage devices.

COURSE CONTENT

Unit I

Introduction: Nanotechnology for sustainable energy- Energy conversion process, indirect and direct energy conversion, use of nanoscale catalysts to save energy and increase the productivity in industry

Unit II

Hydrogen Energy: Hydrogen production methods: from fossil fuels, electrolysis, thermal decomposition, photochemical, photocatalytic, hybrid; Hydrogen storage methods: metal hydrides, metallic alloy hydrides, carbon nanotubes etc.

Unit III

Electrochemical Energy Storage Systems: Batteries: Primary, Secondary, Lithium, solid-state and molten solvent batteries; Lead acid batteries; Nickel Cadmium Batteries; Advanced Batteries. Applications of batteries, light emitting diodes, catalytic reactors, capacitors fuel cells.

Unit IV

Nanomaterials in Energy Storage: Nano-electrochemical systems, nanomaterials for rechargeable batteries, nanomaterials for fuel cells, carbon material for energy storage e.g. Graphene, GO, r-GO, Fullerene and carbon nanotubes and carbon allotropes etc.

Text/References

1. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, (1986).
2. Martin A Green, Solar cells: Operating principles, technology and system applications, Prentice Hall Inc, Englewood Cliffs, NJ, USA, (1981).
3. H J Moller, Semiconductor for solar cells, Artech House Inc, MA, USA, (1993).
4. Ben G Streetman, Solis state electronic device, Prentice Hall of India Pvt Ltd., New Delhi (1995).
5. M.A. Kettani, Direct energy conversion, Addision Wesley Reading, (1970).
6. Linden, Hand book of Batteries and fuel cells, Mc Graw Hill, (1984).
7. Hoogers, Fuel cell technology handbook. CRC Press, (2003).
8. Vielstich, Handbook of fuel cells: Fuel cell technology and applications, Wiley, CRC Press, (2003).

NSC 524 Nanodevices and Sensors (4 Credits)

Introduction / Pre-requisites for the Course: Basic knowledge of chemistry and physics

Course Objective: To study the carbon nanotechnology, nano magnetism, and different sensing techniques

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

Unit-I	LO1	Understand the applications of carbon nanotechnology in various fields
Unit-II	LO2	Learn about various magnetic materials and devices.
Unit-III	LO3	Understand the basics of gas sensors
Unit-IV	LO4	Learn the applications of different sensing techniques like electrochemical, gas sensing etc.

COURSE CONTENT

Unit I

Carbon Nanotechnology: Introduction to carbon nanotubes and their applications in various industries, supercapacitors, hydrogen storage; Nanomaterials for solar power: Solar energy materials, Solar energy devices, silicon solar technology for clean energy, Light Emitting Diodes,OLED displays.

Unit II

Basics of Nanomagnetism, Spintronics technology and the challenges, Modern magnetic materials: principles and applications, Electron and nuclear spin devices.

Unit III

Introduction to Gas sensors; Characteristics of Gas sensors; Types of Gas sensors; Solid State Gas sensors: Chemiresistive Gas sensors (Semiconducting Metal Oxide based sensors, Carbon Nano Tube based nanosensors).

Unit IV

Miscellaneous applications: Microfluidics and Microsystems, Micro-electromechanical systems,

ChemFET (NEMs and MEMS based sensors), Optic Gas sensors, Spectroscopic Gas sensors, Chemical Sensors: Electrochemical Gas Sensors.

Text/References

1. Nanotubes and Nanowires- CNR Rao and A Govindaraj RCS Publishing.
2. Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor
3. Martin A Green, Solar cells: Operating principles, technology and system applications, PrenticeHall Inc, Englewood Cliffs, NJ, USA, (1981).
4. H J Moller, Semiconductor for solar cells, Artech House Inc, MA, USA, (1993).
5. Nanosensors: Physical, Chemical, and Biological by Vinod Kumar Khanna, Publisher: CRC Press.

NSC 523 Semiconductor materials and applications (4 Credits)

Introduction / Pre-requisites for the Course: Understanding of basic Physics		
Course Objective: Introduction to semiconductor materials and applications		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Learn Energy Band Diagram and related concepts.
Unit-II	LO2	Calculate charge carriers in Intrinsic and Extrinsic Semiconductors.
Unit-III	LO3	Learn basics of Semiconductor junction theory and heterojunction.
Unit-IV	LO4	Learn growth and fabrication techniques for Semiconducting Nanostructures.

COURSE CONTENT

Unit I

Electron Theories. Effective mass concept. Density of states concept. Energy Band Diagram: Electron Energy Bands, Semiconductor Heterostructures, Lattice-matched and mismatched heterostructures, Inorganic-organic Heterostructures. Dopant Atoms and Energy Levels, Position of Fermi Energy Level. Excitons, band-gap variations-quantum confinement.

Unit II

Charge Carriers in Semiconductors: Intrinsic and Extrinsic Semiconductors, Equilibrium Distribution of Electrons and Holes in Intrinsic and Extrinsic Semiconductors, Carrier Transport Phenomena: Carrier Drift, Carrier Diffusion, Graded Impurity Distribution, Hall Effect.

Unit III

Basics of Semiconductor junction theory. Semiconductor Electronic devices: p-n Junction, p-n Junction Diode, Metal-Semiconductor and Semiconductor Heterojunctions, rectification in junctions.

Unit IV

Growth and Fabrication Techniques for Semiconducting Nanostructures: Bulk crystal and Heterostructure growth. Applications Semiconductor nanoparticles, Concept of direct and indirect band gap semiconductors, Effect of band gap on Optical luminescence and fluorescence, porous silicon.

Text/References

1. Encyclopedia of Nanotechnology- Hari Singh Nalwa
2. Springer Handbook of Nanotechnology - Bharat Bhusan
3. Handbook of Semiconductor Nanostructures and Nanodevices Vol 1-5- A. A. Balandin, K. L.Wang.
4. Nanostructures and Nanomaterials - Synthesis, Properties and Applications - Cao, Guozhong.

NSC 527: Nanocarriers for drug and gene delivery (4 Credits)

Introduction / Pre-requisites for the Course: Basic understanding of biology and nanocarriers		
Course Objective: Introduce basics of nanocarriers for drug/gene delivery and associated challenges		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Learn basics of drug delivery systems and drug targeting strategies
Unit-II	LO2	Learn about polymeric nanocarriers: types, synthesis, and application
Unit-III	LO3	Learn about dendrimer: types, synthesis, and application
Unit-IV	LO4	Learn about application of nanotechnology for gene delivery and the associated challenges

COURSE CONTENT

Unit I

Introduction about drug delivery systems: Basics of drug delivery, Types-polymer, lipid, metal based drug delivery system and miscellaneous. Drug targeting strategies for site specific drug delivery-passive and active targeting, time and rate controlled drug delivery.

Unit II

Polymer based drug nanocarriers: Classification and types of polymeric nanocarriers, Different methods of polymeric nanocarrier preparation: Precipitation, Emulsion diffusion/Solvent evaporation, Salting out etc. Various applications of polymeric nanocarriers: Theranostic, Imaging etc..

Unit III

Introduction of different dendritic nanostructures, chemical structures, types of dendrimers, methods of preparation-convergent and divergent, physicochemical properties of dendrimers, interaction between drug molecules and dendrimers, applications of dendrimers

Unit IV

Challenges in gene delivery, basic concept, design
of nanotechnology-based systems for gene delivery, Non-viral vectors, formulation strategies,
applications in delivery of genes for different diseases.

Text/References

1. Application of Nanotechnology in Drug Delivery: Edited by Ali Demir Sezer, ISBN 978- 953-51-1628-8, 552 pages, Publisher: InTech, 2. Introduction to Novel Drug Delivery Systems By N.K. Jain 3. Understanding Nanomedicine: An Introductory Textbook by Rob Burgess. 2012 CRC Press 4. Nanomedicine for Drug Delivery and Therapeutics, Editor(s): Ajay Kumar Mishra, 2013, Wiley 5. Medical Nanotechnology and Nanomedicine by Harry F. Tibbals. 2010 by CRC Press Introduction to Nanomedicine and Nanobioengineering, by Paras N. Prasad. 2012, Wiley.

NSC 525 Environmental Nanotechnology (4 Credits)

Pre-requisites for the Course: Fundamental knowledge of biology and environment science		
Course Objective: To learn various aspects of nanomaterials used for environmental application and the methodologies for assessing its impact		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Understand environmental impacts of nanomaterials
Unit-II	LO2	Know about the environmental applications of nanomaterials
Unit-III	LO3	Introduce concept of waste management
Unit-IV	LO4	Learn about different analytical methodologies for studying impact of nanomaterials in environment

COURSE CONTENT
Unit I Introduction: Overview of physical, chemical and biological processes concerning the environment; types, transport and transformation processes of contaminants in air, water and soil; effects of contaminants on environment. Environmental impacts of nanomaterials - Exposure and risk assessment, Dose-response, mechanisms of toxicity; ecotoxicological impacts of nanomaterials.
Unit II Environmental applications of nanomaterials: Mechanism for remediation of aqueous contaminants, photocatalyst; membranes incorporating nanomaterials, transport processes in membrane technology; nanomaterial based adsorbents for water and wastewater treatment – adsorption at metal oxide surfaces, hybrid adsorbents; case studies. Hierarchical self-assembled nano-structures and nanomaterials for adsorption of heavy metals.
Unit III Waste Management: Sustainability and global conditions - Material and solid waste management, Energy management -chemical waste management and green chemistry, Climate change and air emissions management, supply water and waste water management.
Unit IV Analytical methodologies for studying impact of nanomaterials in environment – Atomic absorption spectrometry, inductively coupled plasma spectrometry, chromatography, thermal methods, hyphenated techniques. of nanotechnology-based systems for gene delivery, Non-viral vectors, formulation strategies, applications in delivery of genes for different diseases.
Text/References 1. Wiesner, M.R., and Bottero, J.Y. (Ed.) "Environmental Nanotechnology: Applications and Impacts of Nanomaterials" McGraw-Hill, New York. 2007 2. Diallo, M., Duncan, J., Savage, N., Street, A., and Sustich, R. (Eds). "Nanotechnology Applications for Clean Water" William Andrew. 2008 3. Lead J., and Smith, E. "Environmental and Human Health Impacts of Nanotechnology" John Wiley & Sons. 2009 4. Skoog, D.A., Holler, F.J., and Crouch S.R. "Instrumental Analysis" Clenage Learning India Private Limited, New Delhi. 2007 5. Masters, G.M. and Ela, W.P. "Introduction to Environmental Engineering and Science" Prentice Hall. 2007

NSC 526 NSC: Basics of Nanomedicines (4 Credits)

Introduction / Pre-requisites for the Course: Basic knowledge of nanoparticles and biology		
Course Objective: To learn basics of nanomedicines and their preclinical and clinical studies		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Learn basic concept, rational for designing and materials used in nanomedicines
Unit-II	LO2	Introduce basics of cellular nanoparticle interaction and the mechanism involved
Unit-III	LO3	Learn about basics concept of nanotechnology in imaging and diagnostic
Unit-IV	LO4	Know about preclinical and clinical studies of nanomedicines for translation
COURSE CONTENT		
Unit I Introduction: Concept of nanomedicines, Rationale for designing of nanomedicines, Materials for preparation of nanomedicines, Different structures of nanomedicines.		

Unit II Cellular nanoparticle interaction and receptor-mediated endocytosis: Transport of nanoparticles across the biological barriers, parameters affecting binding and uptake of nanoparticles-size, shape, surface charge, protein corona, surface modification. Different mechanisms of receptor-mediated endocytosis.
Unit III Nanotechnology in imaging and diagnosis: Basic concept of nanotechnology in imaging, Different nanomaterials for imaging and diagnosis, Applications of nanomaterials in MRI, computed tomography and image guided disease treatment.
Unit IV Clinical translation of nanomedicines: Preclinical and clinical considerations of nanomedicines, Overview of current clinical nanomedicines, Regulations of nanomedicines for human health.
Text/References 1. Nanotechnology in Modern Medical Imaging and Interventions. Xiaoming Yang. Nova Science Publisher. 2. The Clinical Nanomedicine Handbook. By Sara Brenner. CRC Press 3. Nanomedicines and Nanoproducts: Applications, Disposition, and Toxicology in the Human Body. Eiki Igarashi. 4. Novel Drug Delivery Systems. by Yie W. Chien 5. Introduction to Novel Drug Delivery Systems By N.K. Jain

SEMESTER IV

NSC 591 Dissertation & Viva (8 C)

Pre-requisites for the Course: Basic knowledge of nanoscience and nanotechnology
Course Objective*:* To provide hands-on-experience on synthesis and applications of nanomaterials for solving the problems related to energy, environment, health, agriculture etc.
Course outcome: On completion of the course, the students will be able to design research proposal, perform experiments, analyze and interpret data, and write and present research outcomes.
Course content: Students are required to carry out a research project of 6 months duration related to Nanoscience/Nanotechnology. Each student will be assigned with a supervisor from among the panel of teachers.

NSC 551 Term paper, Project Proposal and Defence I (4 Credits)

Pre-requisites for the Course: Basic knowledge of nanoscience, nanotechnology and computer
Course Objective To train students in reviewing of literature, analyzing data and presentations.
Course outcome: On completion of the course, the students will be able to 1. understand the literature, analyze data and present effectively. 2. understand the literature, design projects on innovative ideas and present them effectively.
Course content: Students of non-biology background would be required to write a comprehensive review on a contemporary topic. They would be required to formulate a proposal on the basis of the background literature collected and finally defend the proposal.

OPTIONALS

NSC 572:Carbon Nanoscience and its applications (4 Credits)

Pre-requisites for the Course: Understanding of basic Physics		
Course Objective: Introduction to Carbon Nanoscience and its applications		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Learn carbon molecules and their types.
Unit-II	LO2	Learn higher order Fullerenes, their production and purification.
Unit-III	LO3	Understand spectroscopic properties of carbon nanotubes
Unit-IV	LO4	Learn structure, preparation and properties of graphene.

COURSE CONTENT

Unit I

Introduction – Carbon molecules, nature of the carbon bond, new carbon structures, discovery of C60-structure of C60 and its crystal, From a Graphene Sheet to a Nanotube, Single wall and Multi walled Nanotubes, Zigzag and Armchair Nanotubes, Nomenclature, Euler's Theorem.

Unit II

Structure of Higher Fullerenes, Growth Mechanisms; Production and Purification- Fullerene Preparation by Pyrolysis of Hydrocarbons, Partial Combustion of Hydrocarbons, Arc Discharge Methods, Production by Resistive Heating, Rational Syntheses; Physical Properties.

Unit III

Spectroscopic Properties of Carbon Nanotubes- Raman and Infrared Spectroscopy of Carbon Nanotubes, Absorption and Emission Spectroscopy of Carbon Nanotubes, ESR-Spectroscopic Properties of Carbon Nanotubes.

Unit IV

Structure of graphene; Preparation of graphene – synthesis of graphene by various physical and chemical methods and Purification; Electronic Properties Band Structure of Graphene - Mobility and Density of Carriers, Spectroscopic Properties of graphene - Raman, Application of Fullerene, CNT, Graphene and other carbon nanomaterials: Mechanical, Thermal, Electronic, and biological Applications.

Text/References

1. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell.
2. Carbon Nanotechnology- Liming Dai.
3. Nanotubes and Nanowires- CNR Rao and A Govindaraj RCS Publishing.
4. Physical properties of Carbon Nanotube-R Satio.

NSC 574: Basics of Nanotechnology In Tissue Engineering - (4 Credits)

Pre-requisites for the Course: Understanding of basics of biotechnology and nanamaterials		
Course Objective: To learn various aspect of tissue engineering in the context of nanotechnology		
Course outcome: On completion of the course, the students will be able to:		
Unit-I	LO1	Introduce basics concepts of tissue engineering
Unit-II	LO2	Learn about various aspect of tissue engineering and the underlying principles
Unit-III	LO3	Understand about various aspects of biomaterials: biodegradability and biocompatibility
Unit-IV	LO4	Learn about application of Nanotechnology in tissue engineering

COURSE CONTENT

Unit I

Introduction – Stem cells - basic principle - embryonic stem cells - Induced pluripotent stem cells. Structure-function relationships. Native matrix - Tissue Engineering and Cell-Based Therapies -Tissue Morphogenesis and Dynamics- Stem Cells and Lineages - Cell-Cell Communication.

Unit II

Primary cells vs. cell lines- Cell Isolation and Culture - ECM and Natural Scaffold Materials- Scaffold Fabrication and Tailoring. Synthetic Biomaterial Scaffolds- Graft Rejection – Immune Responses-Cell Migration- Micro technology Tools, Principles of self assembly - Cell migration - 3D organization and angiogenesis..

Unit III

Biomaterials for tissue engineering- Biomaterials: ceramics, polymers (synthetic and natural). Biodegradable materials: synthesis and characterization, classification on the basis of origin and material properties. Biocompatibility-various factors that determines it and different studies for certifying biocompatibility.

Unit IV

Application of tissue engineering- Application in stem cell tissue engineering, cardiac cells engineering, Neural cell engineering, Cartilage, Bone, vascular cells, Skin tissue engineering, Ligament etc. Stem Cell Therapies. Nanotechnology-based approaches in the treatment of injuries to tendons and ligaments - Progress in the use of electrospinning processing techniques for fabricating nanofiber scaffolds for neural applications.

Text/References

1. Biomaterials and Nanotechnology for Tissue Engineering by S Sethuraman, U M Krishnan, A Subramanian, 2016, CRC Press
2. Nanotechnology Applications for Tissue Engineering, 1st Edition, Editors: Sabu Thomas, Yves Grohens, & Neethu Ninan. 2015, Elsevier
3. Nanotechnology in Tissue Engineering and Regenerative Medicine, by Ketul Popat. 2010 by CRC Press