

**COURSE STRUCTURE AND SYLLABUS (APPROVED FOR FIRST TWO SEMESTERS)  
M.Sc (Nanotechnology) SCHOOL OF NANO SCIENCES**

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 403	Synthesis of nanomaterials	4
NSC 404	Characterisation of nanomaterials - I	4
NSC 405	Nano Science Practicals – I	4
	M.Sc Semester II (Total Credits -20)	
NSC 451	Nano composites and Nano polymers	4
NSC 452	Nanotoxicology and Biosafety	4
	OPTIONALS FOR GROUP A (NON BIOLOGY/LIFE SCIENCE)	
NSC 471	Mathematics and Computational Science	4
NSC 472	Characterisation of nanomaterials - II	4
NSC 473	Nano Science Practicals – II	4
	OPTIONALS FOR GROUP B (BIOLOGY/LIFE SCIENCE)	
NSC 474	Nanotechnology in agriculture and food processing	4
NSC 475	Nano Biotechnology	4
NSC 476	Nano Science Practicals – III	4
	M.Sc Semester III (Total Credits -16)	
NSC 501	Nano fabrication	4
	OPTIONALS FOR GROUP A (NON BIOLOGY/LIFE SCIENCE)	
NSC 521	Nanomaterials in energy technology	4
NSC 522	Industrial applications of Nano Science	4
NSC 523	Semi conductor materials and applications	4
	OPTIONALS FOR GROUP B (BIOLOGY/LIFE SCIENCE)	
NSC 524	Nanoscience applications in drug delivery	4
NSC 525	Environmental nanotechnology	4
NSC 526	Basics of Nano medicine	4
	M.Sc Semester IV (Total Credits -16)	
NSC 551	Dissertation & Viva	8
	OPTIONALS FOR GROUP A	
NSC 571	Term paper, Project proposal and defense I	4
NSC 572	Carbon Nanoscience and its applications	4
	OPTIONALS FOR GROUP B	
NSC 573	Term paper, Project proposal and defense II	4
NSC 574	Basics of Nanotechnology in Tissue engineering	4
TOTAL		<b>72</b>

**Examination structure: Sessional evaluation - 50%, End semester examination - 50%**

**Sessional evaluation - Mid semester examination - 30%, Assignments - 20%**

#### NSC 401 Physics of Nanomaterials (4C)

- 1) Scales In Nanophysics  
Quantum Structure: 3D-Potential Wells (Spherical & Rectangular Parallelepiped), 2D (Circular & Square, Quantum Corrals), 1D (Quantum Wires), 0D (Quantum Dots).
- 2) Barrier Penetration: Step Potential; Rectangular Barrier Penetration; Tunneling; WKB.  
Applications of Barrier Penetration: TEM, AFM, STM.
- 3) The Harmonic Oscillator: Schrodinger approach; Dirac's bra-ket notation & operator algebra; lattice vibrations; phonons. Hydrogenic Atoms: Spherically Symmetric Potential; Spherical Harmonics; Radial Wave Function; Orbitals.
- 4) Molecular Physics:  $H_2^+$  Molecular Ion; Bonds (Ionic, Covalent, Hydrogen); Molecular Spectrum; Rotational & Vibration Levels; Raman Spectrum; Sigma & Pi Bonds; Carbon Nanotubes; Graphene; Fullerenes, Energy Bands: Fermi-Dirac Statistics; Kronig-Penny Model; Holes; Effective Mass; Density Of States: 3D, 2D, 1D; Conduction & Valence Bands; Semiconductor Physics.

#### TEXT BOOKS:

- 1) A Textbook Of Quantum Mechanics by PM Mathews and K Venkatesan, TMH Publications, 2010
- 2) Quantum Mechanics by Amit Goswami Waveland Press inc., 2003
- 3) Quantum Heterostructures: Microelectronics and Optoelectronics by Valdamir V. Mintin, V. A. Kochelap, M. A. Storscio, Cambridge University Press, 2000
- 4) Modern Physics For Scientists and Engineers by J Talyor, C Zafiratos, MA Dubson, Pearson Education, 2004
- 5) Handbook Of Nanotechnology by Bharatbhushan, Springer Publications, 2010

#### NSC 402 Chemistry of Nanomaterials (4C)

- 1) Structure, bonding & synthesis of some inorganic materials, zeolites, tetravalent metal acid salts, introduction to transition metal complexes, metal carbonyls, organo metal complexes.
- 2) Atomic structure, chemical bonding, aromatic chemistry, polynuclear aromatic hydrocarbons, methods of preparation, physical & chemical properties, molecular orbital's, LCAO method & pericyclic reactions.
- 3) Introduction to Liquid crystals, classification and synthesis of liquid crystals, heterocyclic compounds, classification, numbering, nomenclature, 5 & 6 membered heterocyclic compounds with one or more hetero atoms.
- 4) Zero, 1<sup>st</sup>, 2<sup>nd</sup>, order reaction, theories of reaction rates, statistical thermodynamics, partition functions, Colloidal state, micelles, solid state, bonding in solid state, catalysis by supported metal ion, influence of nano dimensions on catalyst function

#### TEXT BOOKS:

- 1) The Chemistry of Nanomaterials: Synthesis, Properties and Applications, 2 Volumes C. N. R. Rao (Editor), Achim Muller (Editor), Anthony K. Cheetham (Editor), J Wiley & Sons, 2006
- 2) Chemical Functionalization of Carbon Nanomaterials: Chemistry and Applications, Vijay Kumar Thakur, Manju Kumari Thakur, CRC Press, 2015
- 3) Organic Chemistry By Morrison And Boyd, 7<sup>th</sup> Ed
- 4) Nanochemistry: A Chemical Approach to Nanomaterials – by Geoffrey A. Ozin, Andre C. Arsenault, Ludovico Cademartiri and Chad A. Mirkin, Royal Soc Chemistry, 2008

#### NSC 403 Synthesis of nanomaterials (4C)

- 1) The study of techniques such as inert gas condensation, physical vapour deposition, sputtering, plasma deposition process, chemical vapour deposition. Classifications and types of nanomaterials as nano particles and 1D 2D 3D nanomaterials. Concept of bulk versus nanomaterials and dependence of properties on size. Classifications of techniques of nano synthesis based on the nature of the starting phase as vapour, liquid or solid. Introduction to 'Top down' vs. 'Bottom up' approach of synthesis with suitable examples.

2) Nano synthesis techniques based on liquid and vapour phase as the starting material. The study of wet chemical method like sol-gel method, micro emulsion technique, reduction of metal salts, decomposition of organometallic precursors, cryochemical synthesis etc. Study of rapid solidification route, electro and electroless deposition etc. along with suitable examples.

3) Synthesis of 3D nano structured materials using high-energy mechanical attrition by devitrification of an amorphous precursor, etc. Introduction to nanolithography and self-assembly routes. Introduction to specific synthesis processes like synthesis of semiconductor nano particles in colloidal solution, preparation of quantum dots, nano wires and films, preparation of single-walled and multi-walled nanotubes.

4) Brute force methods vs. soft Chemistry routes, sol-gel method of synthesis, Modification, use of templates, microwave and ultrasound assisted synthesis, citrate gel method, CFC(controlled flow cavitations), SCF's(super critical fluids). Introduction to specific synthesis process, nano particles in colloidal solutions, Surfactants, physical chemistry or surfactant behavior, micelles, self assembly, self assembled mono layers (SAM's),Langmuir-Blodget(LB)films, organic block copolymers, emulsion polymerization micro emulsion.

#### TEXT BOOKS

- 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.

#### NSC 404 Characterisation of nanomaterials-I (4C)

- 1) Importance of characterization of materials at nano level. Difference in behavior of materials in bulk and nano regime. Difficulties in charactizing materials of nano size.
- 2) Techniques of characterization of size of nano powders/ particles using BET method and laser diffraction. Determination of specific area and the pore volume for nano porous solids.
- 3) Principle. Scope and application of various spectroscopic techniques like optical spectroscopy. U-V visible and Infrared spectroscopy. Raman spectroscopy. X-ray photoelectron spectroscopy. Basic understanding of each technique with special emphasis on characterization at nano scale.
- 4) Characterization of nano particles in terms of their composition .Crystal structure, phase analysis and crystallite size using X-ray Fluorescence (XRF) ,X-ray diffraction (XRD) and Small Angle X-ray Scattering principles.

#### TEXT BOOKS

- 1) Nanostructures and Nanomaterials, synthesis, properties and applications by Guozhong Cao, Imperial College Press, 2004.
- 2) Nanomaterials – Handbook by Yury Gogotsi, CRC Press, Taylor & Francis group, 2006.
- 3) Nanomaterials: synthesis, Properties and Applictions by Edelstein A S and Cammarata R C,Taylor and Francis, 2012.
- 4) NANOTECHNOLOGY Basic Science and Emerging Technologies by Michael Wilson, Kamali Kannangara and Geoff Smith, A CRC Press Company, D.C, 2002.
- 5) Principles of Instrumental analysis by Douglas A. Skoog, F. James Holler, Sauders college publication, 1998 .
- 6) Hand book of Infrared spectroscopy of ultra thin films by Valeri P. Tolstoy, John Wiley& sons publication, 2003.

#### **NSC 405 Nano Science Practicals – I (4C)**

List of experiments:

- 1) Synthesis of various nanoparticles and analysis by UV-Vis spectrophotometer and DLS. Examples of nanoparticles such as thiolated silver nanoparticles, Gold Nanoparticles, monodispersed polymethylmethacrylate spheres, silver gallium selenide nanoparticle, Zinc selenide quantum dots, Iron Oxide Nanoparticle.
- 2) Synthesis of Nickel metal nanoparticle by hydrothermal technique and to determine particle size Using UV-Vis spectrometer.
- 3) Synthesis of Zinc Oxide semiconducting nanoparticle by co precipitation technique and to calculate the absorption coefficient & optical bandgap using UV-Vis spectrometer
- 4) Synthesis of aqueous ferrofluid by wet chemical methods and Peak analysis of IR Transmission spectrum using FTIR spectroscopy.
- 5) Chemical bath deposition – Dip coating and to calculate the absorption coefficient & optical bandgap using UV-Vis spectrometer

TEXT BOOK:

- 1) Edelstein A S and Cammarata R C, “Nanomaterials: Synthesis, Properties and Applications”, Taylor and Francis, 2012

#### **NSC 451 Nano composites and Nano polymers (4C)**

- 1) Introduction to polymers Importance of polymers: Basic concept-Classification of polymers on the basis of microstructures, macrostructures and applications- Chain Structure and configuration. Homo and heteropolymers - Copolymers-Chemistry of polymerization.
- 2) Polymeric nanostructures and nanocomposites The formation of ordered polymer structures at interfaces- Block copolymers for ordered polymeric nanostructures- Surface micelles and surface induced Nano patterns- Surface nano and microstructuring with organometallic polymers. Polymer/ clay nanocomposites- polypropylene layered silicate nanocomposites biodegradable polymer/layered silicate nanocomposites.
- 3) Metal matrix nanocomposites Metal-containing polymers: cryochemical synthesis, structure, and physicochemical properties-nanostructured polymeric nano reactors for metal nanoparticle formation- optical extinction of metal nanoparticles synthesized in polymer by ion implantation-optically anisotropic metal polymer.
- 4) Ceramic matrix nanocomposites Nanophase ceramic composites- Processing- microstructural control of metal reinforced ceramic matrix nanocomposites- Machinable nanocomposite ceramics. Silicon nitride and silicon carbide based ceramics- Functionally graded ceramics clay nanocomposites.

TEXT BOOKS:

- 1) Polymer Science by Viswanathan V.R., and NV JayaderSreedhar, New age International publications, 2005.
- 2) Polymernanocomposites by Yiu-Wing Mai and Zhong-Zhen yu, CRC press,2006.
- 3) The elements of polymer science and engineering by Alfred Rudin, 2<sup>nd</sup> edition, Academic press publication, 1999.
- 4) Nano and Biocomposites by Alan Kin-TakLau, Farzanahussain, Khalidlafdi, CRC press, 2010.
- 5) Advances in polymer science by Abe, A.-C. Albertsson, R.Duncan, Springer,2006.
- 6) Ceramic matrix composites:Microstructure, properties and applications by Low I. M., Woodhead Publishing Limited, 2006.

#### **NSC 452 Nanotoxicology and Biosafety (4C)**

- 1) Introduction – source of nanoparticles –epidemiological evidence –entry routes into the human body: Lungs – Inhalation – Deposition and translocation – Intestinal tract - Skin – Attributes contributing to nanomaterial toxicology. Nanoparticles in the environment – Health threats- nanomaterials and biotoxicity –Iron oxide –Titanium dioxide-dark studies –UV irradiation- In vivo - In Vitro and cytotoxicity studies.
- 2) Classifications and source of pollutants - Air - Water - Soil - biomarkers – Environmental implication of nanomaterials – Occurrences, Fate and characterisation of Nanomaterials in the environment.
- 3) Toxicology of nanomaterials in food: Characterization of Engineered Nanomaterials: Unique Issues for Characterization of Engineered Nanomaterials for Food Applications - Safety Assessment of Oral exposure Engineered Nanomaterials for Food Application - Experimental Design Considerations for Toxicology Studies - Toxicokinetics – ADME Toxicodynamics - In Vivo Toxicity - In Vitro Toxicity - Study Reliability.
- 4) Nanocomposites for Food Packaging - Nanocomposites for Food Packaging Toxicity and Environmental Risks of Nanomaterials, Physicochemical characteristics of nanomaterials – Nanoparticle interaction with biological membrane – Neurotoxicology - Toxicity of nanoparticles in the EYE.

#### TEXT BOOKS:

- 1) Nanotechnology: Health and Environmental Risks by Jo Anne Shatkin, CRC Press, 2008
- 2) Nanotechnology Environmental Health and Safety: Risks, Regulation, and Management, by Matthew Hull, Diana Bowman, William Andrew, Elsevier 2014
- 3) Nanotechnology - Toxicological Issues and Environmental Safety, by P.P. Simeonova, N. Opopol, M.I. Luster, Springer 2007
- 4) Safety of Nanoparticles: From Manufacturing to Medical Applications by Thomas J. Webster, Springer 2008

#### **NSC 471 Mathematics and Computational Science (4C)**

- 1) Basic Features Of MATLAB: Variables, Comments, Punctuations Matlab Workspace, Simple Math, Complex Numbers, Mathematical Function, Operation On Vectors And Matrices, Logical Arrays. 2D And 3D Graphics. ODE And PDE Solvers, Optimization Tools In MATLAB
- 2) Computer Arithmetic: Floating Point Numbers And Round Off Errors, Absolute And Relative Errors, Polynomial Interpolation: Newton's And Lagrange's Interpolation Formulas, Numerical Integration by Trapezoidal Rule, Simpson's Rule, Error Analysis. Solution Of System Of Linear Equations By Direct Method (Gauss-Elimination) And Iterative Methods (Jacob's Method, Gauss-Seidel Method)
- 3) Solution of Transcendental Equation By Bisection Method And Newton's Method. System Of Non Linear Equations: Newton-Raphson's Method.
- 4) Curve-Fitting by Least Square Techniques. Numerical Solution Of ODE, Single Step Method- Runge Kutta Methods, Numerical Solution To PDE, Stability And Convergence.

#### TEXT BOOKS:

- 1) Higher Engineering Mathematics by B. S. Grewal, Khanna Publishers Delhi
- 2) Introductory Numerical Analysis By S. S. Sastry, Prentice Hall Publishers
- 3) Matlab, An Introduction with Applications by Amos Gilat
- 4) Getting Started with Matlab 7, Oxford Press (Indian Edition 2007)

#### **NSC 472 Characterisation of Nanomaterials – II (4C)**

- 1) Understanding of micro structural developments in nanomaterials using optical microscopy. Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) approach. High resolution Transmission Electron Microscopy (HRTEM).
- 2) Characterizing nano materials using techniques based on scanning probe microscopy principle namely Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM), Magnetic Force Microscopy (MFM) etc. Chemical Force Microscopy (CFM), Focused Ion Beam (FIB), Nanolithography.
- 3) Magnetic measurements using vibrating sample magnetometer (VSM)- magnetic force microscopy (MFM) - Electron Paramagnetic Resonance (EPR)-Nuclear Magnetic Resonance (NMR) spectroscopy – Mechanical properties-micro hardness - nano indentation- elastic and plastic deformation- fracture toughness - superplasticity.
- 4) I-V/C-V - Hall - Quantum Hall effects - Kelvin-probe measurements - Deep level transient spectroscopy (DLTS) - FET characteristics.

#### TEXT BOOKS:

- 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.

#### NSC 473 Nano Science Practicals – II (4C)

- 1) Handling of Atomic Force microscopy
- 2) Operation of Scanning tunneling microscopy
- 3) To determine the surface roughness of AFM images using offline SPM software
- 4) Determination of energy Bandgap of semiconductor by Photoluminescence
- 5) To synthesise quantum dot by chemical route
- 6) Colloidal suspension of nanoparticles
- 7) Preparation and analyses of LB films
- 8) To determine the density of self-assembled Au nanoparticle by AFM
- 9) To study the self-assembly of nanodots by AFM

#### TEXT BOOK

1. Edelstein A S and Cammarata R C, “Nanomaterials: Synthesis, Properties and Applications”, Taylor and Francis, 2012

#### NSC 474 Nanotechnology in agriculture and food processing (4C)

- 1) Intermolecular interactions and supramolecular structures: Water - Hydrophobic and Hydrophilic Interactions - Dispersion Interaction Electrostatic Interactions - Atoms and Small Molecules - Polymers, Particles, and Surfaces - Steric Interactions Involving Soluble Polymers - Depletion Aggregation of Particles by Non-adsorbing Polymers - Bridging Aggregation of Particles by Adsorbing Polymers - Stabilization of Dispersed Particles by Adsorbing Polymers - Polymer Brushes to Prevent Particle Aggregation and Particle Deposition at Surfaces - Plant Cells - Organized Self-Assembled Structures - Langmuir Layers Lipid Bilayers - Solid-Supported Lipid Bilayers.
- 2) Nanoparticles in agricultural and food diagnostics: Enzyme Biosensors and Diagnostics - DNA-Based Biosensors and Diagnostics Radiofrequency Identification- Integrated Nanosensor Networks: Detection and Response- Lateral Flow (Immuno)assay - Nucleic Acid Lateral Flow (Immuno)assay - Flow-Through (Immuno)assays - Antibody Microarrays Surface Plasmon Resonance Spectroscopy.

- 3) 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, Packaging, Encapsulation, Engineering Food Ingredients to Improve Bioavailability - Nanocrystalline Food Ingredients - NanoEmulsions - Nano-Engineered Protein Fibrils as Ingredient Building Blocks Preparation of Food Matrices - Concerns about Using Nanotechnology in food production.
- 4) Nanotechnology in food packaging: Crop improvement - 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 - Information and Communication Technology - Sensors - Radiofrequency Identification Technology- Risks - Consumer and Societal Acceptance.

**TEXT BOOKS :**

- 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 475 Nano Biotechnology (4C)**

- 1) 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
- 2) Structural & Functional Principles Of Bionanotechnology: Lipid Bilayers – liposomes – neosomes- Polysaccharides - Peptides –Nucleic acids – DNA scaffolds – Enzymes- Biomolecular motors: linear, rotary mortors – Immunotoxins – Membrane transporters and pumps – Antibodies – monoclonal Antibodies – immunoconjugates - limitations of natural biomolecules
- 3) Protein And Dna Based Nanostructures: Nanocircuitry - S-layer proteins: structure, chemistry and assembly – lipid chips – S - Layers as Templates – engineered nanopores - DNA–Protein Nanostructures DNA-templated Electronics - DNA-based Metallic Nanowires and Networks DNA–Gold-Nanoparticle Conjugates – DNA -templated Electronics – DNA Nanostructures for Mechanics and Computing
- 4) Nanobio-Analytics: Luminescent Quantum Dots for Biological Labeling - Nanoparticle Molecular Labels - Surface Biology: Analysis of Biomolecular Structure by Atomic ForceMicroscopy and Molecular Pulling - Force Spectroscopy – Biofunctionalized Nanoparticles for Surface - Enhanced Raman Scattering and Surface Plasmon Resonance - Bioconjugated Silica Nanoparticles for Bioanalytical Applications

**TEXT BOOKS:**

- 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.

- 5) Nanobiomaterials Handbook by Balaji Sitharaman, Taylor & Francis Group, 2011.

#### **NSC 476 Nano Science Practicals – III (4C)**

- 1) Synthesis of micelles and inverse micelles.
- 2) Isolation of DNA and Bioconjugation of DNA with Nanoparticles
- 3) Functionalization of nanoparticles with glycans and proteins for drug delivery
- 4) Toxic effect of nanoparticles on microbes, AMES test, effect of NPs on blood cell viability using MTT
- 5) UV/Vis spectrophotometric analysis of effect of NPs on DNA, protein, membrane integrity-study leakage of cytosolic enzymes
- 6) Effect of nanoparticles on metalloenzymes, redox status of blood cells, mitochondrial integrity

#### **TEXT BOOK**

- 1) Nanomaterials: Synthesis, Properties and Applications” by Edelstein A S and Cammarata R C, Taylor and Francis, 2012
- 2) Textbook of Nanoscience and Nanotechnology by T. Pradeep, McGraw Hill Education (India) Private Limited: , 2012