M.Sc. (Nanotechnology) SCHOOL OF NANO SCIENCES
Programme structure and Syllabus

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 given below)	
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**

NSC 401 Physics of Nanomaterials- (4C)

Module 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.

Module 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.

Module 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.

Module 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.

Recommended books:

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 (4C)

Module 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.

Module 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.

Module 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.

Module 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 BOOKS

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 (4C)

Module 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.

Module 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.

Module III: Structural & Functional Principles Of Bionanotechnology: 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

Module 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 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.

NSC 407 Synthesis and Characterization of Nanomaterials (4C)

Module 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.

Module 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

Module 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.

Module 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 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.

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

NSC 441 Nano Science Practical-I (4C)

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.

SEMESTER II

NSC 454 Nanostructured materials and applications (4C)

Module I: Nano Composites and their Applications, Metal-Metal nanocomposites for nuclear energy applications, Magnetic nanocomposites for Spintronics application, Ceramic nanocomposites for high temperature applications.

Module 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.

Module III: Classification of conducting polymers: Intrinsic and extrinsic conducting polymers - Chemical and electrochemical methods of the synthesis of conducting polymers – Applications of conducting polymers in corrosion protection, sensors, electronic and electrochemical energy devices.

Module IV: Miscellaneous applications of nanotechnology: dental implants, consumer products, biomimetic nanomaterials for tissue engineering, biopolymer tagging, semiconductor quantum dots.

TEXT BOOKS

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.

NSC 452: Nanotoxicology and Biosafety (4C)

Module 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.

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

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

Module 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 BOOKS

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 (4C)

Module 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).

Module 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).

Module 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).

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

Recommended 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.

OPTIONALS

NSC 471 Mathematics and Computational Science (4C)

Module 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

Module II: Solution of Transcendental Equation By Bisection Method And Newton's Method. System Of Non Linear Equations: Newton-Raphson's Method. Finite difference method

Module III: Curve-Fitting by Least Square Techniques. Numerical Solution Of ODE, Single Step MethodRunge Kutta Methods, Numerical Solution To PDE, Stability And Convergence.

Module IV: Introduction to molecular dynamics, first principle solution, potential determination, Density Functional Theory (DFT)

TEXT BOOKS:

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 (4C)

Module I: Vacuum Technology: Gas Laws, Kinetic Theory of Gases, Conductance and Throughput, Gas Sources in a Vacuum Chamber, Vacuum Pumps.

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

Module 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).

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

TEXT BOOKS

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 (4C)

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.

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

Module 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.

Module 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.

Module 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 - Nano-Engineered Protein Fibrils as Ingredient Building Blocks.

Module 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.

NSC 478: Basics of Pharmaceutical Sciences (4C)

Module I:

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

Module II:

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

Module III:

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

Module 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.

NSC 492 Nano Science Practical-III (4C)

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

Module I:

Nanofabrication processes: Concept of Top Down and Bottom Up Fabrication approach, Bio-mediated assembly, template assisted synthesis, epitaxial growth.

Module 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.

Module III:

Nanofabrication in semiconductor industry: Metal Oxide Semiconductor (MOS) transistor, NMOS and PMOS transistors, Complementary Metal Oxide Semiconductor (CMOS) transistor

Module 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).

Recommended books:

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 (4C)

Module - 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

Module - 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.

Module - 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.

Module - 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 BOOKS

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 (4C)

Module 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.

Module II:

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

Module 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).

Module III:

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.

Recommended books:

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, Prentice Hall 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 (4C)

Module 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.

Module 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.

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

Module 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 BOOKS

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 (4C)

Module 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.

Module 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.

Module III: Dendritic nanostructures for drug delivery: 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

Module IV: Nanocarriers for gene delivery: 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.

Suggested tutorials:

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 (4C)

Module I – 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.

Module – 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.

Module - 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.

Module – IV Analytical methodologies for studying impact of nanomaterials in environment – Atomic absorption spectrometry, inductively coupled plasma spectrometry, chromatography, thermal methods, hyphenated techniques.

TEXT BOOKS

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 (4C)

Module I: Introduction: Concept of nanomedicines, Rationale for designing of nanomedicines, Materials for preparation of nanomedicines, Different structures of nanomedicines.

Module 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.

Module 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.

Module IV: Clinical translation of nanomedicines: Preclinical and clinical considerations of nanomedicines, Overview of current clinical nanomedicines, Regulations of nanomedicines for human health.

Suggested tutorials:

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)

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

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 (4C)

Module 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.

Module 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.

Module 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.

Module 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 BOOKS:

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 - (4C)

Module 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.

Module 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, Principals of self assembly - Cell migration - 3D organization and angiogenesis.

Module 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.

Module 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.