DEPARTMENT OF PHYSICAL SCIENCE

PREAMBLE :

M.Sc., Nanoscience Programme is supported by the UGC under the XI plan **Innovative Programme** Scheme incorporating, **Teaching and Research in an Interdisciplinary and Emerging Area** from 2011 to 2016.

The theory courses of the program M.Sc Nanoscience program are completely revised. The revised syllabus will be effective from 2013 batch onwards. Eight courses have been designed. Out of which seven are pure theory courses and one is a lab course. The courses are designed in a way, that the physical, chemical and biological approaches to learn Nanoscience have been emphasized equally in all the three semesters.

M.Sc. - Nanoscience

Course Profile

Sem	Course Code	Course Title	Hrs./ Week	Credit
I	PGN1521M	BASIC PHYSICAL AND CHEMICAL CONCEPTS FOR NANOSCIENCE	5	5
	PGN1522M	ESSENTIALS OF NANOSCIENCE	5	5
	PGN1422P	NANOSCIENCE LAB - I	6	4
		ELECTIVE (Physics/Chemistry/Biology/Biotech)	14	15
		Total Hrs./Week	**30**	
II	PGN2524M	A CHEMICAL APPROACH TO NANOMATERIALS	5	5
	PGN2525M	A PHYSICAL APPROACH TO NANOMATERIALS	5	5
	PGN2526M	CELL BIOLOGY AND BIOTECHNIQUES	5	5
	PGN2422P	NANOSCIENCE LAB - II	6	4
		ELECTIVE (Physics/Chemistry/Biology/Biotech)	9	10
		Total Hrs./Week	**30**	
III	PGN3423P	COMPUTATIONAL NANOSCIENCE	6	4
	PGN3624M	APPLICATIONS OF NANOMATERIALS	6	6
	PGN3625M	APPLICATIONS OF NANOSYSTEMS IN MEDICINE	6	6
	PGN3422P	NANOSCIENCE LAB - III	6	4
		ELECTIVE (Physics/Chemistry/Biology/Biotech)	6	5
		Total Hrs./Week	**30**	
IV	PGN4921M	PROJECT WORK	28	9
	PGN4121V	SOCIETAL AND ETHICAL ISSUES (SEI) OF NANOSCIENCE AND NANOTECHNOLOGY	2	1
		Total Hrs./Week	**30**	

PGN1521M BASIC PHYSICAL AND CHEMICAL CONCEPTS FOR NANOSCIENCE

(Theory)

LEARNING OUTCOME : **5 Hrs./Wk.**

On successful completion of the course, the student will be able to

- Recall the basics of thermodynamics, photochemistry and electrochemistry
- Differentiate the classical and quantum approaches.
- recognize the quantum nanostructures.
- understand the principles of Molecular Spectroscopy

COURSE OUTLINE :

UNIT-I : BASICS OF THERMODYNAMICS **15 Hrs.**

Classical equilibrium thermodynamics – The basic concepts - work, heat, energy, enthalpy , extensive and intensive properties – state and path functions – System, surroundings and equilibrium – Laws of thermodynamics – First ,second, third laws- Fundamental equations of thermodynamics.

UNIT-II : BASICS OF ELECTROCHEMISTRY AND PHOTOCHEMISTRY **15 Hrs.**

Electrochemistry – Electrolytic conductance- types of electrodes- electrochemical cells – electrode processes – Electrochemical series- Electromotive force- Nernst equation and its importance – **Photochemistry** – The Jablonskii diagram-Radiative and Non-radiative transitions-laws of photochemistry – Quantum yield – Photophysical processes-Fluorescence, phosphorescence - Chemi and bioluminescence - Photosensitization and quenching.

UNIT-III : INTRODUCTION TO QUANTUM MECHANICS **15 Hrs.**

Quantum theory of radiation- Photoelectric effect, Black body radiation, Compton effect, Bohr's theory of hydrogen atom- Wave particle duality- de Broglie equation - Heisenberg Uncertainity principle- Postulates of Quantum mechanics- Operators in Quantum mechanics- Schrodinger wave equation and solutions to particle in 1- D & 3- D box- Electrons trapped in 3- D (Nanodot)- 2D-(Nanosheet)- 1-D (Nanowire).

UNIT-IV : QUANTUM NANOSTRUCTURES **15 Hrs.**

Introduction to band structure- types of solids – Band theory - Fermi-energy – Conductors – Insulators – Semiconductors – intrinsic, extrinsic, n-type, p-type semiconductors – Energy gap in bulk, atom and nanoclusters – Density of states – Quantum confinement and Bohr exciton radius – Quantum size effect – Quantum nanostructures – Quantum well, wire and dot.

UNIT-V : FUNDAMENTALS OF MOLECULAR SPECTROSCOPY **15 Hrs.**

Introduction to electromagnetic radiation – Properties of EMR – Interaction of EMR with matter – Regions of electromagnetic spectrum – Basic elements of spectroscopy – Absorption and emission spectroscopy – Signal to noise ratio – Resolving power – Width and intensity of spectral lines – Fourier transform spectroscopy – Basic physical principles of vibrational, electronic and magnetic resonance spectroscopy and mass spectrometry.- Application of these techniques to interpret the structure of simple organic molecules.

REFERENCE BOOK(S)

Banwell C.N, **Fundamental of molecular Spectroscopy**, McGraw Hill, 1996, Chapters: Unit : V.

Donald L. Pavia, Lampman, Kriz, Vyvyan, **Spectroscopy**, Rajkamal Electric Press, 2009,

Chapters: Unit: V.

Hornyak, Dutta, Tibbals and Rao, **Introduction to Nanoscience**, New York, CRC press, 2008, Chapters: Unit : III & IV.

K. K. Chattopadhyay, A. N. Banerjee, **Introduction to Nanoscience and Nanotechnology**, New Delhi, PHI Learning Pvt. Ltd, 2009, Chapters: Unit : III.

McQuarrie, Donald A, **Quantum Chemistry**, Chennai, Viva Books Private Limited, 2003, Chapters: Units: III.

Peter Atkins, Julio De Paula, **Atkins' Physical Chemistry**, Eight Edition (International Students Edition), Delhi, New Z.A.Printers, Chapters: Unit : I.

Puri, Sharma, Pathania, **Principles of Physical Chemistry**, Vishal Publishing co, 2005, Chapters: Unit : II.

PGN1522M ESSENTIALS OF NANOSCIENCE

(Theory)

LEARNING OUTCOME : **5 Hrs./Wk.**

On successful completion of the course, the student will be able to

- appreciate the importance of nanoscience
- recognize the different types of nanomaterials.
- understand the properties of nanomaterials.

COURSE OUTLINE :

UNIT-I : EVOLUTION OF NANOSCIENCE AND NANOTECHNOLOGY **15 Hrs.**

History of Nanoscience and Nanotechnology – Ancient, Medieval and Modern period – Terms and Definitions – Scale of materials – macro, micro and nanoscale – pioneers and contributors in nanoscience and nanotechnology – Fabrication methods – Top-down and bottom-up approaches (Principles and types) – Nanoscience and nanotechnology practiced by nature –Inspirations from nature – Natural nanomaterials – Inorganic, organic and biological origin.

UNIT-II : NANOMATERIALS **15 Hrs.**

Structure , properties and importance of the following Nanomaterials - Metallic nanoparticles – Semiconductor quantum dots, core-shell nanoparticles - carbon based nanomaterials – fullerenes, carbon nanotubes (single walled and multi walled) and graphenes – Supramolecules – Dendrimers, micelles and reverse micelles – Nanoporous Materials. (Synthesis of the nanomaterials not included)

UNIT-III : POLYMERIC NANOMATERIALS **15 Hrs.**

Introduction to polymers – classification of polymers – types of polymerization processes – Block copolymers - Glass transition temperature of Polymers – Structure, properties and importance of selected **synthetic and Biopolymers** – Polystyrene, Polyvinyl alcohol, Polystyrene sulphonate, Polyethylene glycol, Polyhydroxy alkanoate, Polylactic acid and Chitosan. – **Conducting polymers** – Introduction, principle of conduction and different types of conducting polymers.

UNIT-IV : PROPERTIES AT THE NANOSCALE - I **15 Hrs.**

Comparison of properties at bulk and nano – Surface and Volume – Surface energy – Surface stabilization – Surface energy minimization mechanisms – Application of classical thermodynamics

to nanomaterials (Small system thermodynamics) – Chemical interactions at Nanoscale.- Primary interactions (Ionic, Covalent and Metallic bonds) – Secondary interactions – Electrostatic interaction, Hydrogen bonding, Van-der waals attraction, hydrophobic effect.

UNIT-V : PROPERTIES AT THE NANOSCALE - II **15 Hrs.**

Optical properties in metals, **semiconductors and insulators**- Photoluminescence - Cathode luminescence- Electro luminescence- Fluorescence- Phosphorescence- Surface Plasmon resonance and optical properties in **metallic nanoparticles** – Quantum confinement and emission characteristics of semiconductor nanocrystals – optical properties of **core-shell nanoparticles** – Mechanical, thermal and electrical properties of **carbon based nanomaterials** (CNT & graphenes) – Guest-Host relationship and Molecular recognition in **supramolecules**.

REFERENCE BOOK(S)

Gabor L.Hornyak, Joy Deep Dutta, Harry F.Tibbals and Hail K.Rao, **Introduction to Nanoscience**, New York, CRC press, 2008, Chapters: Unit : I, IV & V.

Pradeep T, **Nano:The Essentials: Understanding Nanoscience and Nanotecnology**, New Delhi, Tata McGraw-Hill Publishing Company Limited, 2008, Chapters: Unit : II, III & V.

Rao C.N.R, Müller, Cheetham, **The Chemistry of Nanomaterials**, 1 and 2, Wiley- VCH Verlag GmBH & Co., Weinheim, 2004, Chapters: Unit : III.

PGN2524M A CHEMICAL APPROACH TO NANOMATERIALS

(Theory)

LEARNING OUTCOME : **5 Hrs./Wk.**

On successful completion of the course, the student will be able to

- identify the different chemical methods of synthesis of nanomaterials
- gain knowledge on different characterisation techniques
- apply a suitable technique to characterize a nanomaterial
- understand the properties of nanocomposites

COURSE OUTLINE :

UNIT-I : CHEMICAL METHODS OF SYNTHESIS – I **15 Hrs.**

Zero-dimensional nanomaterials – Fundamentals of homogeneous and heterogeneous nucleation – Growth of nuclei – Synthesis of metallic nanoparticles (Chemical reduction method) - Semiconductor nanoparticles (Precipitation methods) – Oxide nanoparticles (Sol-gel process, Hydrothermal methods) – Kinetically confined synthesis of nanoparicles (Micelles, Microemulsion, Aerosols, Template synthesis) – **One dimensional nanomaterials** – Spontaneous growth – Evaporation condensation growth – Vapour (or solution) – Liquid – Solid growth - Template based synthesis of Nanowires and nanorods

UNIT-II : CHEMICAL METHODS OF SYNTHESIS – II **15 Hrs.**

Synthesis of carbon nanotubes – purification, separation, growth mechanisms - **Chemical modification of carbon nanotube** – **Two dimensional nanomaterials** – Chemical Vapour deposition – Types of chemical reactions – reaction kinetics – transport phenomena – CVD methods – Self-assembly – Organosilicon, Alkanethiols and sulfides, carboxylic acids, amines and alcohols – L-B films – Electrochemical deposition - Design and synthesis of selected supramolecules – Dedrimers, calixarenes, crown ethers and molecular squares.

UNIT-III : NANOCOMPOSITES AND FIBRES **15 Hrs.**

Composites and Nanocomposites – **Carbon fibres and Nanotubes** – Types of fibres, whiskers and Nanotubes, synthesis of fibres abd nanotubes, chemical modification of nanotubes – **Organic polymer nanocomposites** – Interfacial area, Nanofilled composite design, synthesis and properties - **Metal and ceramic nanocomposites** – metal nanocomposites, inorganic nanofibres, cermets and concrete - **Clay nanocomposites** – Polypropylene-clay, Montmorillonite clay, Halloysite nanotube clay compsites –Organic-inorganic hybrids – Intercalation compounds.

UNIT-IV : STRUCTURAL CHARACTERIZATION **15 Hrs.**

Introduction to crystallography - fundamental definitions - Nomenclature of crystal directions and crystal planes - Miller indices- Symmetry elements of crystalline solid- Crystal structures- **X- Ray diffraction** and Bragg's law- Fundamental principles, Instrumentation and Applications of : X-ray diffraction techniques – Small angle x-ray scattering – **Ion spectrometry**: Rutherford Back scattering spectrometry - Mass spectrometry (SIMS) – **Microscopic techniques** - Scanning electron microscopy (SEM and FESEM) – Transmission electron microscopy(TEM and HR-TEM) – Scanning probe microscopy (STM and AFM) – Fluorescence and confocal microscopy - Particle size determination based on light scattering.

UNIT-V : SPECTRAL CHARACTERIZATION **15 Hrs.**

Principle, instrumentation and characterization of nanomaterials by absorption and emission spectroscopy, IR, Raman - Vibrational studies of surfaces – EELS, Reflection – absorption spectroscopy, SERS - Photoelecton spectroscopy (XPES, UPES, AES) – X-ray fluorescence.

REFERENCE BOOK(S)

Banwell C.N, **Fundamental of molecular Spectroscopy**, McGraw Hill, 1996, Chapters: Unit : V.

Gabor L.Hornyak, Joy Deep Dutta, Harry F.Tibbals and Hail K.Rao, **Introduction to Nanoscience,**, New York, CRC press, 2008, Chapters: Unit : III & V.

Guozhong Cao, Ying wang, **Nanostructures and Nanomaterials**, (Synthesis, Properties and Applications), World Scientific Publishing Co Pte. Ltd, 2011, Chapters: Unit : I, II & IV.

Rao C.N.R, Müller, Cheetham, **The Chemistry of Nanomaterials**, 1 and 2, Weinheim, Wiley- VCH Verlag GmBH & Co, 2004, Chapters: Unit : V.

V R Gowariker, N V Viswanathan, Jayadev Sreedhar, **Polymer Science**, New age international (P) Ltd., Publishers, 2009, Chapters: Unit : III.

PGN2525M A PHYSICAL APPROACH TO NANOMATERIALS

(Theory)

LEARNING OUTCOME : **5 Hrs./Wk.**

On successful completion of the course, the student will be able to

- identify the different physical methods of synthesis of nanomaterials
- understand the physical properties of different types of nanomaterials
- recall the physical methods of characterization

COURSE OUTLINE :

UNIT-I : SYNTHESIS OF NANOMATERIALS **15 Hrs.**

Fundamentals of film growth – Vacuum science - **Physical vapour deposition techniques** : Thermal evaporation – Electron beam evaporation – sputtering – inert gas condensation - ion

plating – pulsed laser deposition – Molecular Beam Epitaxy – **Mechanical method** : Ball milling - **Thermal method** : Electro-spinning - **Lithography**: Photolithography – Electron beam lithography – X-ray lithography – Focused ion beam lithography-soft lithography – nanoimprint lithography.

UNIT-II : MECHANICAL AND ELECTRICAL PROPERTIES **15 Hrs.**

Crystal imperfections - Point, Line, Surface and Volume defects- Effect of crystal imperfections – defects in nanocrystalline material - Influence of Grain size on Physical Properties- **Mechanical properties** :Young's modulus - Stress-strain – Hardness and strength – Tensile ductility and strain hardening – Creep and superplastic behavior – Fracture and toughness – Corrosion properties – **Bulk metallic and ceramic materials**: Influence of porosity – Weibull theory – Flexural strength – Fracture toughness – Superplasticity. **Electrical Properties:** Electrical conductivity – Surface scattering – Change of electronic structure – Quantum transport: Ballistic conduction, Coulomb blockade, Tunneling conduction – Effect of microstructure.

UNIT-III : MAGNETIC AND THERMAL PROPERTIES **15 Hrs.**

Magnetic properties: Different types of magnetic materials - Hard and soft magnetic materials - Magnetic phenomena and their classical interpretation – The Nano perspective – Characteristics of Nanomagnetic systems – Characteristics of Nanomagnetic materials – Superparamagnetisim, GMR and CMR - Physical properties of Magnetic nanostructures: substrate effects on structures and related properties – oscillatory exchange coupling – Spin-polarized tunneling – Magnetoresistivity – Magnetic moments of 3D transition metal clusters - The temperature dependence of magnetic moments. Thermal Properties: Thermal conductivity and heat transfer – Ballistic and Diffusive Heat Transport.

UNIT-IV : MAGNETIC AND THERMAL CHARACTERIZATION **15 Hrs.**

Magnetic force Microscopy (MFM) - Vibrating Sample Magnetometer (VSM) Superconducting quantum interference device (SQUID) – Electron Holography – Lorentz Microscopy - Scanning Thermal probe microscopy- Thermal Gravimetry Analysis (TGA)- Differential Thermal Analysis (DTA)- Differential Scanning Calorimetry (DSC)

UNIT-V : MECHANICAL AND ELECTRICAL CHARACTERIZATION **15 Hrs.**

Nanotribology: Nanotribometer - Surface Force Apparatus (SFA) - Quartz Crystal Microbalance(QCM) - Friction Force Microscope (FFM) - MEMS & NEMS - Nanoindentation (Hardness Measurements)- Four Probe measurement - Hall effect¬ - Kelvin Probe Force Microscopy

REFERENCE BOOK(S)

B.S. Murty,P Shankar,Baldev Raj, B.B. Rath, James Murday, **Textbook of Nanoscience and Nanotechnology**, University Press, India PVT, 2013, Chapters: Unit : II).

Dieter Vollath, **Nanomaterials an Introduction to Synthesis, Properties and Applications**, KgaA,Weinheim, WILEY-VCH Verlag GmbH & Co, 2008, Chapters: Unit : II.

Gabor L.Hornyak, Joy Deep Dutta, Harry F.Tibbals and Hail K.Rao, **Introduction to Nanoscience**, New York, CRC press, 2008, Chapters: Unit : III.

Guozhong Cao, Ying wang, **Nanostructures and Nanomaterials**, (Synthesis, Properties and Applications), World Scientific Publishing Co Pte. Ltd, 2011, Chapters: Unit : II.

H.Hopster, H.P.Oepen (Eds.), **Magnetic Microscopy of Nanostructures**, Springer – Verlag

Berlin, 2005, Chapters: Unit : IV.

Peter M. Martin, **Handbook of deposition technologies for films and coatings science, application and technology**, USA, Elsevier, 2010, Chapters: Unit : I.

T.Pradeep, **Nano: The Essentials, understanding Nanoscience and Nanotechnology**, New Delhi, Tata McGraw-Hill Publishing Company Ltd, 2007, Chapters: Unit : V.

W. R. Fahrner (Ed.), **Nanotechnology and Nanoelectronics, materials, devices, measurement techniques**, Springer- Verlag Berlin Heidelberg,, 2005, Chapters: Unit : I.

PGN2526M CELL BIOLOGY AND BIOTECHNIQUES

(Theory)

LEARNING OUTCOME : **5 Hrs./Wk.**

On successful completion of the course, the student will be able to

- understand the fundamental concepts of biology in relation to pharmacology.
- appreciate the use of techniques involved in understanding the activity of drugs.
- utilize the significance of toxicology in 'in vivo and in vitro' studies.
- imbibe the value of nature in synthesis of nanomaterials.

COURSE OUTLINE :

UNIT-I : CELL STRUCTURE AND FUNCTION **15 Hrs.**

Cell structure (prokaryotes, plant and animal cell); organelle structure and their function: Plasma membrane, cytoplasm, nucleus, mitochondria, Endoplasmic reticulum and ribosome, golgi complex; cell environment, cell transport methods and cell-cell interactions (Adhesion junctions, Tight junctions, gap junctions, plasmodesmata).

UNIT-II : BIOMOLECULES AND MOLECULAR PROCESSES **15 Hrs.**

Structure and function of carbohydrates (monosachharides disaccharides, polysaccharides); proteins (Amino acid, peptides) – enzymes; lipids (simple, complex and derived) and nucleic acid (DNA and RNA), Outline of replication, Transcription and translation in animal cells; post transcriptional and translational modification.

UNIT-III : BIOMOLECULAR TECHNIQUES **15 Hrs.**

Separation of Macromolecules (SDS PAGE, isoelectric focusing, 2D gel electrophoresis, AGAROSE electrophoresis);Diagnostic technique (antibody-based), Toxicity assays (LC50/LD50, Micronuclei assay, sperm abnormality assay, chromosomal aberration assay, comet assay, MTT assay, LDH assay).

UNIT-IV : CELL PHYSIOLOGY, DRUG ACTION AND TOXICOLOGY **15 Hrs.**

Neurophysiology: Blood brain barrier, neuronal communication (transmission of neural impulses, action potential, synapses and neurotransmitters); Physiological factors influencing drug interaction and effect (Temperature, pH, salt concentration, availability of allosteric and inhibitory molecules); Biotransformation; mode of action of xenobiotics, Retention time, contra indications, Biocompatability and toxicity (ADMEX), excretion of toxicants via kidney, lungs, feces, sweat, saliva, milk.

UNIT-V : BIONANOMATERIAL **15 Hrs.**

Peptide - and protein-based nanomaterial (self assembling peptides and myosin) Carbohydrate-based nanomaterial (Glyconanoparticles) and lipid-based (solid lipid nanoparticles) Nucleic acids-

based (probe molecules); functionalization and modification of these nanobiomaterials; use of bacteria, fungi, actinomycetes, viruses and plants for nanomaterial synthesis.

REFERENCE BOOK(S)

Alberts, B., Bray. D., Hopkin. K, Johnson. A., Lewis. J., Raff. M., Roberts, K., and Walter. P, **Essentials of Cell biology**, 2nd edition, New York, Garland Science, 2004, Chapters: Unit : I.

C.M.Niemeyer, C.A. Mirkin, **Nano biotechnology concepts, applications and perspectives**, Wiley VCH Verlag GmbH & co, 2004, Chapters: Unit : V.

Castro, Merchut, Neafsey and Wurster, **Neuroscience – an outline approach**, USA, Mosby Inc, 2002, Chapters: Unit : IV.

Cooper G.M., and Hausman R.E, **The cell, A molecular approach**, 5th edition, Washington D.C.,, ASM press, 2009, Chapters: Unit : I.

Cox M.M. and Nelson D.L., Lehninger, **Principles of Biochemistry**, 5th edition, Newyork, W. H. Freeman & company, 2008, Chapters: Unit : II.

Davidson. V.L., and Sittman. D.B, **NMS Biochemistry**, Fourth Edition, Baltimore, USA, Lippincott Williams & Wilkins, 1999, Chapters: Unit : II.

Giese, **Cell Physiology**, Toranto, W.B. Saunders Company, 1979, Chapters: Unit : IV.

Hornyak G.L., Tibbals.H.F., Dutta J. and Moore J.J, **Introduction to Nanoscience & Nanotechnology**, New York, CRC press Taylor & Francis, 2009, Chapters: Unit : I.

Kocsis, A. and Molnar, H, **Genotoxicity-Evaluation**, testing and prediction, USA, Nova science publication, 2009, Chapters: Unit : III.

Sambrook, J., and Russel. D.W, **Molecular Cloning: A Laboratory Manual**, Third Edition, volume I, New York,, Cold Spring Harbor press, 2009., Chapters: Unit : III.

Subramanian M.A, **Toxicology- Principles and methods**, Chennai,, MJP Publishers, 2004, Chapters: Unit : III & IV.

PGN3423P COMPUTATIONAL NANOSCIENCE

(Lab)

LEARNING OUTCOME : **6 Hrs./Wk.**

On successful completion of the course, the student will be able to

- Explain the principle for the various compujtational techniques.
- Apply the computational principles to solve a given problem in naomaterials
- Perform a computational study on selected problems.

COURSE OUTLINE :

EXPERIMENTS/LAB : **90 Hrs.**

Principles of Computational Modelling: Computer modeling methods for studying materials on different length and time scales - Introduction and principle of **Ab initio methods – Semiempirical methods – Density functional Theory – Molecular mechanics – Statistical mechanics - Molecular dynamics and Monte Carlo simulations – Finite Element Analysis** - Choice of a method – combinations of methods (Hybrid methods). **COMPUTATIONAL SIMULATIONS**

1. Molecular dynamics of carbon nanotubes
2. Monte carlo simulation of a classical liquid

3. Modeling solids with DFT – Density of states and Band structure
4. Molecular dynamics of protein modeling
5. Simulation of network models in biology
6. Quantitative Structure Activity Relationship Analysis of a selected group of molecules and their activity.
7. Finite Element method of determining the property of a nanomaterial.

REFERENCE BOOK(S)

David Young, **Computational Chemistry A Practical guide for applying Techniques to Real world Problem**, Canada, John Wiley & Sons, 2001.

Sarhan M. Musa, **Computational Nanotechnology Modeling and Applications with MATLAB**, CRC Press Taylor & Francis, 2012.

PGN3624M APPLICATIONS OF NANOMATERIALS

(Theory)

LEARNING OUTCOME : **6 Hrs./Wk.**

On successful completion of the course, the student will be able to

- familiarize different nano electronic devices
- appreciate the applications of nanosensors and nanocatalysts
- analyze the significant role of nanomaterials in environment and energy

COURSE OUTLINE :

UNIT-I : NANOELECTRONICS **18 Hrs.**

Introduction – MOSFET structures – Heterojunctions: Modulation-doped heterojunctions, SiGe strained heterostructures – Hot electrons in parallel transport – Resonant tunneling - MODFETs – Heterojunction bipolar transistors – Resonant tunnel effect – Hot electron transistors – Resonant tunneling transistor – Single electron transistor – Molecular electronics - DNA computing.

UNIT-II : OPTOELECTRONICS **18 Hrs.**

Optical properties of quantum wells, superlattices, quantum dots and nanocrystals - Electro-optical effects in quantum wells -superlattices – Optoelectronic devices – Heterostructure semiconductor lasers – Quantum well semiconductor lasers – Vertical cavity surface emitting lasers (VCSELs) – Strained quantum well lasers – Quantum dot lasers – Quantum well and superlattice photodetectors – Quantum well modulators.

UNIT-III : CATALYSIS AND SENSORS **18 Hrs.**

Fundamentals of Catalysis – Homogeneous and heterogeneous catalysis – Adsorption – Surface reactions – Preparation of catalyst and nanocatalysts – Catalytic applications of metal nanoparticles – Carbon based nanomateials – Semiconductors. Classification of sensors – Sensor properties – Chemical and electrochemical sensors – Metaloxide based sensors – Chemiresistors – Nanomaterials in sensor applications.

UNIT-IV : PHOTOCHROMIC AND ELECTROCHROMIC MATERIALS **18 Hrs.**

Photochemistry and Electrochemistry of Nanoassemblies (Metal and Semiconductor Nanostructures) – Photoinduced Charge Transfer Processes in Semiconductor Nanoparticle Systems – Photoinduced Transformations of Metal Nanoparticles – Electrochemistry of

Semiconductor Nanostructures – Electrochemistry of Metal Nanostructures – Semiconductor – Metal Nanocomposites – photocatalytic transformations - Photochromic and Electrochromic Materials.

UNIT-V : ENERGY AND ENVIRONMENT **18 Hrs.**

Energy- Introduction to batteries, fuel cells, super capacitors, solar cells (photovoltaics) and photochemical decomposition of water. Applications of nanomaterials in photovoltaics- Energy production and conversion (Water splitting, fuel cells) – Energy storage (Batteries, supercapacitors) **Environment**-Environmental remediation and mitigation or preventive processes using nanomaterials from air, contaminated waste water, ground water, surface water and soil. **Nanoproducts in market and their commercial applications**.

REFERENCE BOOK(S)

C.N.R. Rao, A. Muller, A.K. Cheetham, **The Chemistry of Nanomaterials Synthesis, Properties and Applications**, Vol.2,, WILEY-VCH Verlag GmbH & Co. KgaA, Weinheim, 2004, Chapters: Unit : IV.

Dieter Vollath, **Nanomaterials an Introduction to Synthesis, Properties and Applications,**, WILEY-VCH Verlag GmbH & Co. KgaA, Weinheim, 2008, Chapters: Unit : IV.

Gabor L.Hornyak, Joy Deep Dutta, Harry F.Tibbals and Hail K.Rao, **Introduction to Nanoscience**, New York,, CRC press, 2008, Chapters: Unit : V.

J. C. Kuriacose, **Catalysis**, Madras, Indian Institute of Technology, 1991, Chapters: Unit : III.

J.M. Martinez- Duart, R. J. Martin- palma, F. Agullo-Rueda, **Nanotechnology for microelectronics and Optoelectronics**, Elsevier B.V, 2006, Chapters: Unit : I & II.

John Vetelino, Aravind Reghu, **Introduction to Sensors**, CRC Press, 2011, Chapters: Unit : III.

W. R. Fahrner (Ed.), **Nanotechnology and Nanoelectronics, materials, devices, measurement techniques,**, Springer- Verlag Berlin Heidelberg, 2005, Chapters: Unit : II.

PGN3625M APPLICATIONS OF NANOSYSTEMS IN MEDICINE

(Theory)

LEARNING OUTCOME : **6 Hrs./Wk.**

On successful completion of the course, the student will be able to

- Understand the importance of value added bio-molecules.
- Utilize the techniques involved in tissue engineering.
- Identify the significance of various nano carriers in therapeutics and diagnostics.
- Acquaint with medical implants and its potential use.

COURSE OUTLINE :

UNIT-I : APPLICATION OF NANO BIOLOGICAL MATERIALS **18 Hrs.**

Synthesis and applications of: peptide- based, Protein-based, (Nanomotors: Bacterial (E.coli) and Mammalian (Myosin family) Carbohydrate -based (s-layers) and lipid based (Glyco Quantum Dots, crystalline cellulose, lectins) nano biological materials for molecular recognition; Lipids – Liposomes, cubosomes and hexosomes; solid lipid nanoparticles (SLP); Nucleic acids-based (lattices, cages and networks); DNA protein hybrid, surface bio-conjugation - functionalization and modification of these nanobiomaterials.

UNIT-II : BASICS OF TISSUE ENGINEERING **18 Hrs.**

Introduction to tissue engineering - stem cells for tissue engineering- scaffolds in tissue engineering; Tissue inducing factors - scaffold materials (polymers, biomimetics and peptides); Scaffolds application in neural, cardio vascular and musculo skeletal tissue engineering- Electro spun scaffolds in tissue engineering.

UNIT-III : APPLICATIONS OF TISSUE ENGINEERING **18 Hrs.**

Medical implants (artificial organs and scaffolds or biosynthetic coatings); tissue regeneration - biocompatibility and reduced rejection ratio; retinal, cochlear and neural implants; regenerative medicine - repair of damaged nerve cells, and replacements of damaged skin, tissue, or bone (scaffold for repair of chondrocytes and regeneration of vascular tissues, CNT/ CNF composite matrix for neural implant, nano implant for bladder tissue replacement).

UNIT-IV : NANO DIAGNOSTICS **18 Hrs.**

Cantilever chips- DNA and protein based biosensors – components, fabrication and application of biosensors. Medical diagnostic products (quantam dots, magnetic nanoparticles) for imaging and detection of tumors, genetic defects and other disease states- Nano robotics- logic and intelligence embedded into medical devices- stand alone sensing and computing devices.

UNIT-V : NANO CARRIERS AND THERAPEUTICS **18 Hrs.**

Applications of organic nanocarriers (Dendrimer, liposomes, nanocapsules, hydrogels and aerosols) and inorganic nanocarriers (Metal, ceramic and zeolite) in nano therapeutics; Functionalised nanocarriers (Pegylated and Glyconanocarrriers); Targeted drug delivery (with reference to cancer, central nervous system, cardio vascular systems) Gene delivery and vaccine delivery; Factors influencing targeted drug delivery (Temperature, pH, Temperature and pH combined, magnetic forces).

REFERENCE BOOK(S)

Fisher J.P., Mikos A.G. and Bronzino J.D, **Tissue engineering**, Florida, CRC press Taylor & Francis, 2007., Chapters: Unit : II.

Hornyak G.L., Tibbals.H.F., Dutta J. and Moore J.J, **Introduction to Nanoscience & Nanotechnology**, New York, CRC press Taylor & Francis, 2009, Chapters: Unit : I, III & V.

Laurencin, C.T., and Nair, L.S.,, **Nanotechnology and tissue engineering**, The scaffold, New York, CRC press, Taylor and Francis group,, 2008, Chapters: Unit : II.

Malsch N.H, **Biomedical nanotechnology**, I Indian reprint, Florida, CRC press Taylor & Francis, 2012, Chapters: Unit : II.

Sharon, M., Sharon. M., Pandey. S and Oza. G, **Bionanotechnology – Concepts and applications**, New Delhi, Ane Books, 2012, Chapters: Unit : V.

Trivedi P.C, **Nanobiotechnology**, Jaipur,, Avishkar publishers, 2008, Chapters: Unit : III & IV.

Vyas S.P, Murthy R.S.R, and Narang R.K, **Nanocolloidal carriers-site specific and controlled drug delivery**, New Delhi, CBS publishers and Distributers, 2011, Chapters: Unit : IV.

Evaluation Pattern of the Student (PG)

Sem	Course Code	Course Title	Offer To	Cour. Type	Total Hrs./ Week		FORMATIVE										SUMMATIVE				
							Test Assn		Quiz Seminar		FLab		Project	Mini Project	Term Paper	Total	Theory		Lab Viva	Exam Hrs.	
					TH	LA	No	RM	No	RM	No	RM	RM	RM	RM		RM	GM	RM	TH	Lab
I	PGN1521M	BASIC PHYSICAL AND CHEMICAL CONCEPTS FOR NANOSCIENCE	SPNAN	TH	5	--	1 1	30 10	1 1	10 10	--	--	--	--	--	60	40	100	-- --	3.00	--
I	PGN1522M	ESSENTIALS OF NANOSCIENCE	SPNAN	TH	5	--	2 2	40 10	-- 1	-- 10	--	--	--	--	--	60	40	100	-- --	3.00	--
II	PGN2524M	A CHEMICAL APPROACH TO NANOMATERIALS	SPNAN	TH	5	--	2 2	40 10	-- 1	-- 10	--	--	--	--	--	60	40	100	-- --	3.00	--
II	PGN2525M	A PHYSICAL APPROACH TO NANOMATERIALS	SPNAN	TH	5	--	2 2	40 10	-- 1	-- 10	--	--	--	--	--	60	40	100	-- --	3.00	--
II	PGN2526M	CELL BIOLOGY AND BIOTECHNIQUES	SPNAN	TH	5	--	2 2	40 10	-- 1	-- 10	--	--	--	--	--	60	40	100	-- --	3.00	--
III	PGN3423P	COMPUTATIONAL NANOSCIENCE	SPNAN	LA	--	6	-- --	-- --	-- --	-- --	1	75	--	--	--	75	--	--	25 --	--	6.00
III	PGN3624M	APPLICATIONS OF NANOMATERIALS	SPNAN	TH	6	--	1 2	30 20	-- 1	-- 10	--	--	--	--	--	60	40	100	-- --	3.00	--
III	PGN3625M	APPLICATIONS OF NANOSYSTEMS IN MEDICINE	SPNAN	TH	6	--	1 2	30 20	-- 1	-- 10	--	--	--	--	--	60	40	100	-- --	3.00	--

TH-Theory; LA-Lab; LT-Lab-cum-Theory; PR-Project; RM-Required Maximum; GM-Given Maximum; Column of Offer To=> AU-Aided UG; SU-Self-Financed UG; AP-Aided PG; SP-Self-Financed PG; SM-MPhil; SD-Diploma; ALLM-All Major; ALLS-All Science; ALLH-All Humanities