BRANCH-Nanotechnology

2nd Semester

Specialization: Nanotechnology

Second Semester							
	Theory				Practical		
Course Name	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ Week L/T**	**Credit Practical**	**Marks**
Specialization Core-1 Mathematical Modeling & Simulation	4-0	4	100	50	-	-	-
Specialization Core-2 Fabrication Techniques & Characterization of Nanomaterials	4-0	4	100	50	-	-	-
Elective-I (Specialization related) 1.Nanoparticles & microorganisms, Bionano composite 2.Nanocomposites 3.Quntum Mechanics 4. Physicochemical Methods for Characterization of Nanomaterials	4-0	4	100	50	-	-	-
Elective-II (Departmental related) 1. Biosensors 2. MEMS & Bio MEMS 3.Nanobiotechnology 4.Advance Nanomaterials	4-0	4	100	50	-	-	-
Elective-III (from any Department) 1.Nanotechnology in Health Care 2. Nanotechnology for Energy System 3.Green Nanotechnology 4.Bio Informatics 5. Semiconductor Nano Structure & Nanoparticles	4-0	4	100	50	-	-	-
Lab-2 (Specialization lab to be decided by the Department)					4	4	150
Seminar/Project					4	4	150
Total							
Total Marks: 1050							
Total Credits: 28							

BRANCH-Nanotechnology

2nd Semester

Specialization: Polymer Nanotechnology

Second Semester							
	Theory				Practical		
Course Name	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ Week L/T**	**Credit Practical**	**Marks**
Specialization Core-1 Nanofabrication Technology	4-0	4	100	50	-	-	-
Characterization of Polymeric Nanomaterials	4-0	4	100	50	-	-	-
Elective-I (Specialization related) 1. Nanomaterials for Energy & Environment 2. Polymer based Optical, Electronic & Magnetic Materials	4-0	4	100	50	-	-	-
Elective-II (Departmental related) 1.Micro/Nanofluidics - Design & Modeling 2. Nanopolymers in Medicine	4-0	4	100	50	-	-	-
Elective-III (from any Department) 1. Technology, innovation and quality Management 2. Mechanics of Finite Size Elements 3.Green Nanotechnology	4-0	4	100	50	-	-	-
Lab-2 (Specialization lab to be decided by the Department)					4	4	150
Seminar/Project					4	4	150
Total							
Total Marks: 1050							
Total Credits: 28							

DETAILED SYLLABUS OF SECOND SEMISTER M.TECH 2016-17 ADDMISSION BATCH

BRANCH-Nanotechnology

Specialization: Nanotechnology

Second Semester							
	Theory				Practical		
Course Name	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ Week L/T**	**Credit Practical**	**Marks**
Specialization Core-1 Mathematical Modeling & Simulation	4-0	4	100	50	-	-	-
Specialization Core-2 Fabrication Techniques & Characterization of Nanomaterials	4-0	4	100	50	-	-	-
Elective-I (Specialization related) 1.Nanoparticles & microorganisms, Bionano composite 2.Nanocomposites 3.Quntum Mechanics 4. Physicochemical Methods for Characterization of Nanomaterials	4-0	4	100	50	-	-	-
Elective-II (Departmental related) 1. Biosensors 2. MEMS & Bio MEMS 3.Nanobiotechnology 4.Advance Nanomaterials	4-0	4	100	50	-	-	-
Elective-III (from any Department) 1.Nanotechnology in Health Care 2. Nanotechnology for Energy System 3.Green Nanotechnology 4.Bio Informatics 5. Semiconductor Nano Structure & Nanoparticles	4-0	4	100	50	-	-	-
Lab-2 (Specialization lab to be decided by the Department)					4	4	150
Seminar/Project					4	4	150
Total							
Total Marks: 1050							
Total Credits: 28							

MATHEMATICAL MODELING AND SIMULATION

Unit-I FUNDAMENTAL PRINCIPLES OF NUMERICAL METHODS: Scientific Modeling – Numerical operations – Numerical Algorithms – Numerical Programs – Numerical Software – Approximations in Mathematical Model building – Numerical integration - Differentiation – Variation finite element methods- Rayleigh's method –Ritz method.

MATHEMATICAL MODELING: Mathematical modeling- physical simulation- advantage and limitations- process control – Transport phenomena- concept of physical domain and computation domain assumption and limitations in numerical solutions- Finite element method and Finite difference method.

Unit-II DIFFERENTIAL EQUATIONS & APPLICATIONS: Euler method, Multi step-differential equations-boundary values-Elliptic equations-one dimensional parabolic equation-hyperbolic equation- partial differential equations-separation of variables-wave equation-Laplace equation-nonlinear partial differential equations-approximation methods of nonlinear differential equations.

Unit-III SIMULATION: Base concepts of simulation-data manipulation, data exchange of the structure, properties and processing of materials- Three dimensional model for capillary nanobridges and capillary forces, Molecular dynamics simulation.

Unit-IV MONTE CARLO METHODS: Basics of the Monte Carlo method-Algorithms for Monte Carlo simulation- Applications to systems of classical particles-modified Monte Carlo techniques-percolation system-variation Monte Carlo method-diffusion Monte Carlo method – Quantum Monte Carlo method.

References:

1. S.C Chapra and R.P Canale, "Numerical methods for Engineers",Tata McGraw Hill, New Delhi, 2002.

2. EnwinKreyzig,"Advance Engineering Mathematics ", John Wiley & Sons, 2004.

3. R.J Schilling and S.L. Harris, "Applied Numerical Methods for Engineers using MATLAB and C", Thomson publishers, New Delhi, 2004.

4. D. Frenkel and B Smith, "Understanding molecular simulation from algorithm to applications", Kluwar Academic Press, 1999.

5. K. Ohno, K. Esfarjani and Y. Kawazoe, "Introduction to Computational Materials Science from ab Carlo Methods", Springer-verlag, 1999.

FABRICATION TECHNIQUES AND CHARACTERISATION OF NANOMATERIALS

Unit-I

Fabrication of Nanomaterials by Physical Methods: Inert fas condensation, Arc discharge, RF-plasma, Plasma arc technique, Ion sputtering, Laser ablaton, Laser pyrolysis, Ball Milling, Molecular beam epitax, Chemical vapour deposition method and Electro deposition.

Unit-II

Scanning Electron Microscopy (SEM.), Scanning Probe Microscopy(SPM), TEM and EDAX analysis, X-ray diffraction.

Unit-III

OpricalMicrosope and their description, operational principle and application for analysis of nanomaterials, UV – VIS-SIR Spectrophotometers, Principle of operation and application for band gap measurement

Unit- IV

M based nanolithography and nanomanipulation, E beam lithography and SEM based nanolithography and nanomanipulation, Ion beam lithography, oxidation and metallization. Mask and its application, Deep UV lithography, X- ray based lithography.

Reference:

1. Fabrication of fine pitch gratings by holography, electron beam lithography and nano-imprint lithography(Proceeding Paper) Authors(s):Darren Goodchild;AlexeiBogdanov;SimonWingar; Bill Benyon; Nak Kim; Frank Shepherd

2. Microfabrication and Nanomanufarturing- Mark James Jackson

3. AThree Beam Approach to TEM Preparation Using In-situ Low Voltage Argon Ion Final Milling in FIBSEM Instrument E L Principe, P Gnauck and p Hoffrogge, Mocroscopy and Microannalysis (2005), 11:830-831 Cambridge Univeristy Press.

4. Processing & properties of structural nanometerials – Leon L. Shaw (editor)

NANOPARTICLES & MICRO-ORGANISMS, BIONANOCOMPOSITES

Unit – I Biological Methods of Synthesis: Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural spynthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis

UNIT – II Microorganisms for synthesis of nanomaterials and for toxicity detection Natural and artificial synthesis of nanoparticles in microorganisms; Use of microorganisms for nanostructure formation, Testing of environmental toxic effect of nanoparticles using microorganisms;

Unit – III Nanocomposite biomaterials, teeth and bone substitution, Natural nanocomposite systems as spider silk, bones, shells; organic-inorganic nanocomposite formation through self-assembly. Biomimetic synthesis of nanocomposite material; Use of synthetic nanocomposites for bone, teeth replacement.

Unit – IV Nanobio Systems**,** Nanoparticle-biomaterial hybrid systems for bioelectronic devices, Bioelectronic systems based on nanoparticle-enzyme hybrids; nanoparticle based bioelectronicbiorecognition events. Biomaterial nanocircuitry; Protein based nanocircuitry; Neurons for network formation. DNA nanostructures for mechanics and computing and DNA based computation; DNA based nanomechanical devices. Biosensor and Biochips.

References:

1. Bionanotechnology: Lessons from Nature by David S. Goodsell
2. Nanomedicine, Vol. IIA: Biocompatibility by Robert A. Freitas
3. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology - Hari Singh Nalwa
4. Nanobiotechnology; ed. C.M.Niemeyer, C.A. Mirkin.
5. Nanocomposite Science & Technology Ajayan, Schadler& Braun
6. BioMEMS (Microsystems) - Gerald A. Urban
7. Introduction to Nanoscale Science & Technology (Nanostructure Science & Technology) - Massimiliano Di Ventra
8. Nanosystems: Molecular Machinery, Manufacturing, and Computation - K. Eric Drexler
9. Springer Handbook of Nanotechnology - Bharat Bhushan
10. Nanobiotechnology; ed. C.M.Niemeyer, C.A. Mirkin.
11. Nanofabrication towards biomedical application: Techniques, tools, Application and impact – Ed. Challa S., S. R. Kumar, J. H. Carola.
12. Nanomedicine, Vol. I: Basic Capabilities
13. Nanomedicine, Vol. IIA: Biocompatibility - Robert A. Freitas
14. Dendrimers I, II, III, Ed. F. Vogtle

NANOCOMPOSITIES

Unit – I

Nano Ceramics Metal-Oxide or Metal-Ceramic composites. Different aspects of their preparation techniques and their final properties and functionality.

Metal based nanocomposites

Metal-metal nanocomposites, some simple preparation techniques and their new electrical and magnetic properties.

Unit - II

Design of nanocomposites : Super hard nanocomposites , its designing and improvement of mechanical properties.

Unit -III

New **kind of nanocomposities**Fractal based glass-metal nanocomposites, its designing and fractal dimesion analysis Electrical property of fractal based nanocomposites. Core-Shell structured nanocomposites.

Unit – IV

Polymer based nanocomposites Preparation and characterization of diblockCoplymer based nanocomposites; Polymer – carbon nanotubes based composites, their mechanical properties, and industrial possibilities.

References

1. Nanocomposites Science and Techology- P.M Ajayan , L.S Schadler, P.V. Braun

2. Physical Proterties of Carbon Nanotubes – R.Saito

3. Carbon Nanotubes (Carbon , Vol 33) – M. Endo, S. lijima, M.S Dresselhaus

4. The search for novel, superhard materials – Stan Veprijek(Review Article) JVST A , 1999

5. Electromagnetic and magnetic properties of multi component metal oxides, hetero

6. Nanometer versus morometer-sizes particles Christian Brosseau, Jamal Ben, Youssef, Philippe Talbot, Anne- Marie Konn, (Review Article) J .Appl. Phys, Vol 93,2003

7. Diblock Copolymer,-Aviram(Review Article), Nature , 2002

QUANTUM MECHANICS

UNIT-I

Introduction: Wave-particle duality, Schrödinger equation and expectation values, Uncertainty principle

Basics of Quantum mechanics: Solutions of the one-dimensional Schrödinger equation for free particle, particle in a box, particle in a finite well, linear harmonic oscillator. Reflection and transmission by a potential step and by a rectangular barrier.

UNIT-II

Solution of Time independent Schrödinger equation: Particle in a three dimensional box, linear harmonic oscillator and its solution, density of states, free electron theory of metals. The angular meomentum problem. The spin half problem and properties of Pauli spin matrices.

UNIT-III

Approximate methods: Time independent and time dependent perturbation theory for non-degenerate and degenerate energy levels, the variational method, WKB approximation, adiabatic approximation, sudden approximation

UNIT-IV

Quantum computation: Concept of quantum computation, QuntumQbits etc.

Books and References:

1. Modern Physics - Beiser
2. Quantum Mechanics - Bransden and Joachen
3. Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, 2nd Edition by Eisberg, Robert; Resnick, Robert
4. Quantum Physics – A. Ghatak
5. Principles of Quantum Mechanics 2nd ed. - R. Shankar
6. Quantum Mechanics - Vol 1&2 - Cohen-Tannoudji

PHYSICOCHEMICAL METHODS FOR CHARACTERIZATION OF NANOMATERIALS

UNIT-I

X-RAY DIFFRACTION: X-ray powder diffraction – single crystal diffraction techniques - Determination of accurate lattice parameters - structure analysis - profile analysis - particle size analysis using Scherer formula.

THERMAL ANALYSIS METHODS: Principle and Instrumentation of Thermogravimetry; Differential Thermal Analysis and Differential scanning calorimetry-Importance of thermal analysis for nanostructures.

UNIT-II

QUALITATIVE AND QUANTITATIVE ANALYSIS: Electron Energy Loss Spectroscopy; High Resolution Imaging Techniques- HREM, Atom probe field ion microscopy-X-Ray Photoelectron Spectroscopy, X-Ray Characterization of Nanomaterials – EDAX and WDA analysis – EPMA – ZAP corrections.

UNIT-III

SPECTROSCOPIC TECHNIQUES: Introduction to Molecular Spectroscopy and Differences-With Atomic Spectroscopy-Infrared (IR) Spectroscopy and Applications- Microwave Spectroscopy- Raman Spectroscopy and CARS Applications-Electron Spin Resonance Spectroscopy; New Applications of NMR Spectroscopy; Dynamic Nuclear Magnetic Resonance; Double Resonance Technique.

UNIT-IV

NANOINDENTATION: Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions- models for interpretation of nanoindentation load-displacement curves-Nanoindentation data analysis methods-Hardness testing of thin films and coatings- MD simulation of nanoindentation.

References:

1. B. D.Cullity, “Elements of X-ray Diffraction”, 4th Edition, Addison Wiley, 1978.

2. M. H.Loretto, “Electron Beam Analysis of Materials”, Chapman and Hall, 1984.

3. R.M.Rose, L.A.Shepard and J.Wulff, “The Structure and Properties of Materials”, Wiley Eastern Ltd,

4. B.W.Mott, “Micro-Indentation Hardness Testing”, Butterworths, London, 1956.

BIOSENSORS

Unit – I

Protein based biosensors- nano structure for enzyme stabilization – single enzyme nano particles – nano tubes microporus silica – protein based nano crystalline Diamond thin film for processing.

DNA based biosensor – fluorescence – absorption – electrochemical. Interation of various Techniques – DNA zymoBiosensors .

Unit – II

Detection in Biosensors – fluorescence – absorption – electrochemical . Integration of various Techniques – Fibre optic Blosensors.

Unit – III

Fabrication of biosensors – techniques used for microfabrication- microfabrication of electrodes – on chip analysis.

Unit – IV

Future direction in biosensor research –designed protein pores- as components of biosensors – Moleculardesing – Bionanotechnology for cellular biosensing- Biosensors for drug discovery- Nanoscale biosensors.

Reference:

1. Biosensor : A Practical Approach, J. Cooper &C.Tass, Oxford University Press, 2004.

2. Nanomaterials for Biosensors, Cs. Kumar, Wiley-VCH,2007.

3. Smart Biosensor Techonology ,G.KKnoff , A.S Bassi, CRC Press, 2006

MEMS AND BIO MEMS

Unit – I

MEMS microfabrication- Fabrication – design and application scalling issues- scalling fluidic biological systems – influence of scaling on material properties.

MEMS mask layout – physics of mems –scaling laws heat transfer- mechanics and electrostatics – batch cabtication – circuit integration.

Unit – II

Bio MEMS – engineering micro fluids-bio mems for fenomics and post genomics- microfluids for bio-diagnosis lead discovery platforms.

Unit – III

MATERIALS FOR MEMS Materials for mems and pro mems-silicon-metals and polymers.

Unit – IV

COMMERCIAL AND TECHNOLOGICAL TRENDS Commercial trends in miniaturization – High density chip analysis – lab – in – chip for DNA and protein analysis – Nano HPCL system.

Reference:

1. Marc Madou, Fundamentals of Microfabtrication, CRC Press 1997.

2. Julian W. Gardner, Microsesors: Principles and Applications, Wiley 1994.

3. Gregory Kovacs, Micromachined Transducers Sourcebook, McGraw- Hill 1998.

4. Hector J. De Los Santos, Introduction to Microelectromechanical (MEM) Microwave Systems <Artech House 1999.

5. Sergey Edward Lyshevski, Nano –and Microelecromechanical Systems, CRC Press2000.

6. Vijay Varadan, Xiaoningjiang, and VasundaraVarandan, Microstereolithography and other Fabrication Techniques for 3D MEMS, Wiley 2001.

7. Tai-Ran Hsu, MEMS and Microsystems: Design and Manufature, McGraw- Hill 2001.

8. Remco J. WiegeringkMikoElwenspoek, Mechanical Microsensors (Microtechology and MEMS), Springer Verlag 2001.

NANOBIOTECHNOLOGY

Module I

Introduction and scope of Nano Biotechnology, comparison of Biotechnology to Nano biotechnology, Nanobiomacines: Negligible gravity and intertia, atomic granularity, thermal motion, water environment and their importance in nanobiomachines. The role of proteins, amino acids, nucleic acids, lipids and polysaccharides in modern biomaterials. Overview of natural Bionanomachines; Thymidylate synthetize, ATP synthetize, Actin and myosin, opsin, Antibodies and collagen.

Module II

Synthesis of Biomolecules: Recombinant Technology, Site-directed mutagenesis, Fusion Proteins. Quantum Dot structures and their integration with biological structures. Tools of Analysis: X-Ray crystallography, NMR spectroscopy, Electron microscopy and Atomic force microscopy. Molecular modelling tools: Graphic visualization, structure and functional prediction, Protein folding prediction and the homology modelling, Docking simulation and Computer assisted molecular design.

Module III

Structural principles of Nano biotechnology raw materials: Factors governing biomolecular structure and stability, Protein folding; Self-assembly, Self-organization, Molecular recognition and Flexibility of biomaterials. Functional principles of Nano biotechnology: Information driven Nano assembly, Energetics, Role of enzymes in chemical transformation, allosteric motion and covalent modification in protein activity regulation, Structure and functional properties of Biomaterials, Bimolecular motors: ATP Synthetase and flagellar motors, Traffic across membranes: Potassium channels, ABC Transporters and Bacteriorhodopsin, Bimolecular sensing, Self-replication, Machine-Phase Bio nanotechnology.

Module IV

Fields of Application: Designer proteins, Peptide nucleic acids, Nanomedicine, Drug delivery, DNA computing, Molecular design using biological selection, Harnessing molecular motors, Artificial life, Hybrid materials, Biosensors, Future of Bio nanotechnology.

Text books:

1. David S Goodsell,Bio nanotechnology, John Wiley & Sons, 2004.

2. Greco Ralph S, Nanoscale Technology in Biological Systems, CRC Press, 2005.

ADVANCED NANOMATERIALS

Unit – I

Fundamentals of magnetic materials, Dia, Para , Ferro , Antiferro , Ferri, Superparamagnatic materials AND giant and colossal magneto- resistance. Important properties in relation to nanomagnetic materials.

Unit – II

Nanostructure Magnetism: Effect Bulk Nanostructuring of Magnetic property; Giant and colossal Magnetic resistane; Super Para Magnetism in metallic nanopartcle; Super para magnetism/FM in Semi- conduction quantum dots.

Unit – III

Carbon Nano Structures: Introduction; Fullerence, C60, C80 and C240 Nanostructures; Properties & Applications (mechanical, optical and electrical).

Unit – IV

Thermo Electric Materials (TEM) : Concept of phonon, Thermal conductivity, Specific heat, Exothermic & endothermic processes Different types of TEM; Bulk TEM Proteries. One dimensional TEM; Composite TEM; Applications.

Reference:

1. NocelNanocrustalline Alloys and Magnetic Nanomaterials – Brian Cantor

2. Physics of Magnetism – S. Chikazumi and S.H. Charap.

3. Physical Theory of Magnetic Domains – C. Kittel.

4. Magnetostriction and Magnetomechanical Effects – E. W. Lee.

5. Nanoscale materials – Liz Marzan and Kamat.

6. Physical properties of Carbon Nanotube – R Satio.

7. Applied Physics of Carbon Nanotubes: Fundamentalof Theory, Optics And Transport Devices S. Subramony& S.V. Rotkins.

8. Carbon Nanotues: Properties and Applications – Michael J. O'Connell

9. CARBON NANOTECHOLOGY – Liming Dai.

10. Nanotubes and Nanowires – CNR Rao and AGovindraj RCS Publishing.

11. CRC Handbook of Thermoelectrics, Ed. CR Rowe

NANOTECHNOLOGY IN HEALTH CARE

UNIT-I

NANOTECHNOLOGY IN PHARMACEUTICAL APPLICATIONS. Human anatomy – Form function and physiology – Developmental prolog - principle of development – Neurophysiology – sensory physiology and muscle physiology - Trends in nanobiotechnology - Protein- and peptide-based compounds for cancer, diabetes, infectious diseases and organ transplant- therapeutic classes-focused pharmaceutical delivery systems.**IMMUNOASSAY TECHNIQUES:** Understanding of antibody-based diagnostic techniques (immunoassay) - micro- and nano-immunosensors- Bio-Barcode Assay-use of magnets, gold, DNA and antibodies- therapies and diagnostics for cancer and central nervous system disorders.

UNIT-II

IMPROVED MEDICAL DIAGNOSTICS: Improved diagnostic products and techniques- i*n vivo* imaging capabilities by enabling the detection of tumors, plaque, genetic defects and other disease states-ability to control or manipulate on the atomic scale- Nanobot medical devices- logic and intelligence embedded into medical devices- standalone sensing and computing devices.

UNIT-III

PROSTHETIC AND MEDICAL IMPLANTS: New generations of prosthetic and medical implants-artificial organs and implants- artificial scaffolds or biosynthetic coatings- biocompatibility and reduced rejection ratio- retinal, cochlear, and neural implants, repair of damaged nerve cells, and replacements of damaged skin, tissue, or bone.

UNIT-IV

METHODS FOR DIAGNOSIS: Animation of the PCR - DNA Profiling - Cantilever Sensors - Targeted Drug Delivery - Magnetic Nanoparticles - Cancer cell targeting - Stem Cell Scaffolds - Electrochemical Impedance Spectroscopy (EIS) - Tethered Lipid Membranes.

References:

1. Chemical Sensors and Biosensors; Brian, R Eggins; Wiley; New York, Chichester; 2002.

2. Biosensors and modern biospecific analytical techniques, Wilson & Wilson's Comprehensive Analytical Chemistry; Ed. L Gorton; Elsevier, Amsterdam, London; 2005.

3. The Immunoassay Handbook; Ed. David Wild; 3rd ed.; Amsterdam: Elsevier; 2005.

4. Electrochemical Methods: Fundamentals and Applications; Allen J Bard and Larry R Faulkner; Wiley, New York, Chichester : 2nd ed.; 2001.

5. Ultrathin Electrochemical Chemo- and Biosensors: Technology and Performance in Springer Series on Chemical Sensors and Biosensors; Volume Two; Ed. Vladimir M. Mirsky; Springer, Berlin; 2004

NANOTECHNOLOGY FOR ENERGY SYSTEMS

Unit – I

INTRODUCTION: Nanotechnology for sustainable energy- Materials for light emitting diodes- batteries- advanced turbines- catalytic reactors- capacitors-fuel cells.

RENEWABLE ENERGY TECHNOLOGY:Energy challenges, development and implementation of renewable energy technologies – nanotehology enabled renewable energy technologies – Energy transport, conversion and storage, Nano , micro and meso scale phenomena and devices.

Unit – II

MICRO FUEL CELL TECHNOLOGY:Micro-fuel cell technologies, intergration and performance for micro-fuel cell systems thin film and microfabrication methods – design methodologies – micro-fuel cell power sources,

Unit – III

MICROFLUIDIC SYSTEMS: Nano – electromechanical systems and novel microfluidic devices – nano engines – driving mechanisms – power generation – microchannel battery – micro heat engine (MHE) fabrication – thermocapillary forces – Thermocapillary pumping(TCP)- piezoelectric membrane.

Unit-IV

HYDROGEN STOREAGE METHODS: Hydrogen storage methods – metal hydrides – size effects – hydrogen storage capacity – hydrogen reaction kinetics – carbon – free cycle – gravimetric and volumetric storage capacities – hydriding/dehydriding kinetics – high enthalpy of formation – and thermal management during the hydriding reaction – distinctive chemical and physical properties materials for automotive applications.

Reference:

1. J.Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986
2. Hydrogen from Renewable Energy sources by D. Infield ,
3. Fuel Storage on Board Hydrogen Storage in Carbon Nanostructures by R.A Shatwell.
4. Fuel cell technology handbook. Hoogers. CRC Press,2003.
5. Handbook of fuel cells: Fuel cell technology and applications Vielstich. Wiley, CRC Press, 2003.

GREEN NANOTECHNOLOGY

Module I

Introduction to nanomaterials:
Nanoparticles preparation techniques, Greener Nanosynthesis:
Greener Synthetic Methods for Functionalized Metal Nanoparticles, Greener Preparations of Semiconductor and Inorganic Oxide Nanoparticles, green synthesis of Metal nanoparticles, Nanoparticle characterization methods,

Module II

Nanomaterials for "Green" Systems:
Green materials, including biomaterials, biopolymers,
bioplastics, and composites Nanotech Materials for Truly Sustainable Construction: Windows,
Skylights, and Lighting. Paints, Roofs, Walls, and Cooling. Multifunctional Gas Sensors, Biomimetic
Sensors, Optical Interference Sensors Thermo-, light-, and stimulus-responsive smart materials Nanomaterials

Module III

Nanomaterials for Alternative Energy:
Nanomaterials for Fuel Cells and Hydrogen
Generation and storage, Nanostrcutures for efficient solar hydrogen production, Metal Nanoclusters in Hydrogen Storage Applications, Metal Nanoparticles as Electrocatalysts in Fuel
Cells, Nanowires as Hydrogen Sensors, Ceramic nanocomposites for alternate energy and environment protection, Applications for Cobalt Nanoparticles and Graphite Carbon-Shells, Nanomaterials for Solar Thermal Energy and Photovoltaic. Semiconductor Nanocrystals and Quantum Dots for Solar Energy Applications Nanoparticles for Conducting Heat Transfer

Module IV

Nanomaterials in Energy Storage Devices:
MWNT for Li Ion Batteries, Nanomaterials in
Electrodes, Hybrid Nanotubes: Anode Material, Supercapacitor, Battery Electrodes
Metal nanocluster catalysts for Coal Liquefaction. Nanomaterials for Desalination and Purification of Water.

Reference:

[1] Nanotechnology for Photovoltaics, by Loucas Tsakalakos, ISBN:9781420076745, Publisher: CRC Press, Publication Date: April 2010.
[2] Dahl, 1. A.; Maddux, B. L. S.; Hutchison, 1. E. Toward Greener Nanosynthesis. Chemical Reviews, 2007, 107,
2228-2269.
[2] Nanomaterials, nanotechnologies and design: an introduction for engineers By M. F. Ashby, Daniel L. Schodek,
Paulo J. S. G. Ferr
[3] Nanoscale materials By Luis M. Liz-Marzán, Prashant V. Kamat
[4] Environmental applications of nanomaterials: synthesis, sorbents and sensors By Glen E. Fryxell, Guozhong Cao
[8]. Global roadmap for ceramics and glass technology By Mrityunjay Singh, Gary S. Fischman, Stephen Freiman,
John Hellmann, Kathryn Logan, Tom Coyle, Wiley 2007
[9] On Solar Hydrogen and Nanotechnology By Lionel Vayssieres Wiley, 2009
[10] Green Nanotechnology: Solutions for Sustainability and Energy in the Built Environment
[11] Geoffrey B. Smith, University of Technology, Broadway, Australia; Claes-Goran S. Granqvist, Uppsala University, Sweden CRC Press ISBN: 9781420085327, Publication Date: August 31, 2010.

Bio Informatics

MODULE-I

Sequence-alignment methodologies: Sequence databases; Similarity matrices; Pairwise alignment: Features of dynamic Programming, alignment by Bayesian Statistical Methods, multiple sequence alignment: local multiple sequence alignment: MEME, PSSM, HMM(algorithms and applications) Progressive methods for global multiple sequence alignment: CLUSTALW, PILEUP, T-COFFEE; Statistical significance of alignment results;

MODULE-II

Pattern analysis in sequences and Phylogenetic tree construction methods: Motif representation, Markov models; .Distance Based methods: clustering based methods,optimality based methods: Fitsch -Margoliash and Minimum evolution methods, Neighbor joining and related neighbor methods Character Based methods: Maximum parsimony methods, Maximum likely hood method, genetic algorithm, Phylogenetic tree evaluation: Boot strap analysis; dendrogram and applications .

MODULE-III

Structure-Prediction of Biomolecules with applications in Bioinformatics: Structure classification of proteins (SCOP, CATH); Secondary structure prediction of various protein categories (e.gtransmembrane proteins and helical proteins), RNA secondary structure prediction methods.

MODULE-IV

Patterns, motifs and Profiles in sequences: Derivation and search methods; Derived Databases of patterns, motifs and profiles e.gProsite, Blocks, Prints-S, Pfam; Overview of tertiary structure prediction methods; algorithms for modeling protein folding; algorithms for 3D structure prediction with representative examples Protein structure prediction by comparative modelling approaches (homology modeling and fold recognition); ab initio structureprediction methods.

SEMICONDUCTOR NANOSTRUCTURES & NANO-PARTICLES

UNIT-I

SEMICONDUCTOR FUNDAMENTALS: Introduction to Semiconductor physics – Fabrication techniques – Semiconductor nanostructures – Electronic structure and physical process – Principles of semiconductor nanostructures based electronic and electro-optical devices – Semiconductor Quantum Dots – Quantum Lasers – Quantum Cascade Lasers – Quantum Dot Optical Memory.

UNIT-II

SEMICONDUCTOR NANOPARTICLE SSYNTHESIS: Cluster compounds, quantum-dots from MBE and CVD, wet chemical methods, reverse micelles, electro-deposition, pyrolytic synthesis, self-assembly strategies.

PHYSICAL PROPERTIES: Melting point, solid-state phase transformations, excitons, band-gap variations-quantum confinement, effect of strain on band-gap in epitaxial quantum dots, single particle conductance.

UNIT-III

SEMICONDUCTOR NANOPARTICLES – APPLICATIONS: Optical luminescence and fluorescence from direct band gap semiconductor nanoparticles, surface-trap passivation in core-shell nanoparticles, carrier injection, polymer-nanoparticle, LED and solar cells, electroluminescence, barriers to nanoparticle lasers, doping nanoparticles, Mn-Zn-Se phosphors, light emission from indirect semiconductors, light emission form Si nanodots.

UNIT-IV

SEMICONDUCTOR NANOWIRES: Fabrication strategies, quantum conductance effects in semiconductor nanowires, porous Silicon, nanobelts, nanoribbons, nanosprings.

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

BRANCH-Nanotechnology

Specialization: Polymer Nanotechnology

Second Semester							
Theory					**Practical**		
Course Name	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ Week L/T**	**Credit Practical**	**Marks**
Specialization Core-1 Nanofabrication Technology	4-0	4	100	50	-	-	-
Characterization of Polymeric Nanomaterials	4-0	4	100	50	-	-	-
Elective-I (Specialization related) 1.Nanomaterials for Energy & Environment 2. Polymer based Optical, Electronic & Magnetic Materials	4-0	4	100	50	-	-	-
Elective-II (Departmental related) 1.Micro/Nanofluidics - Design & Modeling 2. Nanopolymers in Medicine	4-0	4	100	50	-	-	-
Elective-III (from any Department) 1.Technology, innovation and quality Management 2. Mechanics of Finite Size Elements 3.Green Nanotechnology	4-0	4	100	50	-	-	-
Lab-2 (Specialization lab to be decided by the Department)					4	4	150
Seminar/Project					4	4	150
Total							
Total Marks: 1050							
Total Credits: 28							

NANOFABRICATION TECHNOLOGY

Module I (9 hours)

Physical Methods: Inert gas condensation, Arc discharge, RF-plasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapour deposition method and other variants, Electrodeposition.

Module II (13 hours)

Chemical Methods: Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Sonochemical routes, Liquid-liquid interface, Hybrid methods, Solvated metal atom dispersion, Post-synthetic size-selective processing. Sol- gel, Micelles and microemulsions, Cluster compounds.

Module III (12 hours)

Biological Methods: Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis.

Module IV (10 hours)

Lithographic Techniques: AFM based nanolithography and nanomanipulation, E-beam lithography and SEM based nanolithography and nanomanipulation, Ion beam lithography, oxidation and metallization. Deep UV lithography, X-ray based lithography.

Text Books

1. Hari Singh Nalwa - Encyclopedia of Nanotechnology.
2. Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens
3. Processing & properties of structural nanomaterials by Leon L. Shaw (editor)

Reference Books

1. Microfabrication and Nanomanufacturing- Mark James Jackson
2. Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor
3. Nanomaterials Handbook- YuryGogotsi
4. Springer Handbook of Nanotechnology - Bharat Bhusan
5. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al.
6. Synthesis of Nanostructured Materials –Cao
7. Handbook of Nanoscience, Engineering- Goddard et al

CHARACTERIZATION OF POLYMERIC NANOMATERIALS

Module I (10 hours)

Compositional surface analysis: Ultraviolet (UV) and X-ray photoelectron spectroscopy (XPS), Secondary ion mass spectrometry (SIMS)

Module II (10 hours)

Microscopies: Optical microscopy, fluorescence & confocal microscopy, Cathodoluminescence (CL) and photoluminescence (PL), TEM, SEM

Module III (10 hours)

Probe techniques: Atomic force microscopy (AFM), scanning tunnelling microscopy (STM), scanning nearfield optical microscopy (SNOM), deep level transient spectroscopy (DLTS)

Module IV (10 hours)

Kelvin-probe measurements, Nanoscale current-voltage (I-V), capacitance-voltage (C-V) relationships, thermal & thermo-mechanical analysis (DSC, TGA, DMA)

Text Books

1. Turi; Edith A. (Ed.), Thermal Characterization of Polymeric Materials, Academic Press Inc., New York (1981).
2. Sawyer; Linda C. and Grubb; David T., Polymer Microscopy, Chapman and Hall, London (1987).
3. Mitcheli Jr.; John, Applied Polymer Analysis and Characterization-Recent Development in Techniques, Instrumentation, Problem Solving, Hanser Publishers, Munich (19--).
4. Ishida; Hatsud, Characterization of Composite Materials, Butterworth Heinemann, Boston (1994).
5. Haines; Peter J., Thermal Method of Analysis: Principles, Applications and Problems, 3rd Edition, Blackie Academic and Professional, London (1995).

Reference Books

1. Nanostructures & Nano Materials :Ghuzang Cao
2. Hand Book of Nanophase: Zhong Lin Wang (Springer) & Nanomaterials (Vol. I&II)
3. Microstructural Characterization of Materials - David Brandon and Wayne Kaplan, John Wiley and Sons, New York, NY, 1999.
4. Elements of X-ray Diffraction – BD Cullity and SR Stock, Prentice Hall, New Jersey, 2001.
5. Scanning Electron Microscopy and X-Ray Microanalysis - Joseph I Goldstein, 3rd ed., Dale E. Newbury Academic / Plenum Publishers, New York, 2003.
6. Transmission Electron Microscopy - David B Williams and Barry Carter, Plenum Press, NY. London 1996 (or a newer edition).
7. Principles of Instrumental Analysis - Douglas A Skoog, F. James Holler and Timothy A. Nieman, 4th Edition ©1998.

NANOMATERIALS FOR ENERGY & ENVIRONMENT

Module I (8 hours)

Energy Overview: Energy Characteristics - Fundamentals of environment, Environmental impact assessment, Nanomaterials used in energy and environmental applications and their properties. Nanomaterials in automobiles.

Module II (10 hours)

Improvements in solar energy conversion and storage; better energy-efficient lighting; stronger and lighter materials that will improve energy transportation efficiency; use of low-energy chemical pathways to break down toxic substances for remediation and restoration; and better sensors and controls to increase efficiency in manufacturing and processing.

Module III (12 hours)

Device applications Energy – Hydrogen Storage and Production – Fuel Cells – Battery – Carbon Nanotubes for energy storage, Hydrogen Storage in Carbon Nanotubes, Use of nanoscale catalysts to save energy and increase the productivity in industry, Rechargeable batteries based on nanomaterials.

Module IV (12 hours)

Pollution by Nano-particles, Waste remediation: Nanoporous polymers and their applications in water purification, Photo-catalytic fluid purification. Energy conversion, Hierarchical self-assembled nano-structures for adsorption of heavy metals.

Text Books

1. W.F. Kenney: Energy Conservation in the Process Industries, Academic Press, 1984
2. Tetsuo Soga, Nanostructured Materials For Solar Energy Conversion, Elsevier
3. Robert K, Ian H, Mark G, Nanoscale Science and Technology, john Wiley & sons Ltd., 2005

POLYMER BASED OPTICAL, ELECTRONIC & MAGNETIC MATERIALS

Module I (10 hours)

Introduction. Recent past, the present and its challenges, Future, Overview of basic Nanoelectronics. Molecular Electronics Components. Characterization of polyphenylene based switches and complex molecular devices. Molecular rectifying diode switches.

Module II (10 hours)

Nanophotonics: Background, Photonic Properties of Nanomaterials; Photon Absorption, Emission & Scattering; Permittivity & free Electron Plasma of metals, Extinction Coefficient of Metal particles; Gold & silver particles ,Semiconductors: Tuning the Band gap of Nanoscale Semiconductors, Laser & uses of Quantum Dots, Lasers based on Quantum Confinement ,Near Field Light, Optical Tweezers, Photonic Crystals

Module III (12 hours)

Semiconductor nanowires- Fabrication strategies, quantum conductance effects in semiconductor nanowires, porous Silicon, nanobelts, nanoribbons, nanosprings. Nanoelectronic&Nanocomputer architectures: Introduction to nanoelectronic and nanocomputers, Quantum DOT cellular Automata (QCA), Single electron circuits, molecular circuits for Nanocomputer Architecture.

Module IV (12 hours)

Nanostructured ferromagnetism, effect of bulk nanostructuring of magnetic properties, dynamics of nanomagnets, Nanocarbonferromagnets, Giant & colossal magnetoresistance, Nanopore containment of magnetic particles,

Text Books

1. Nanotechnology Understanding Small Systems, Rogers Pennathur Adams, CRC Press, Taylor & Francis Group.

2. Nanoelectronics&Nanosystems: From Transistor to Molecular & Quantum Devices: Karl Goser, Jan Dienstuhl and others.

3. Introduction to Nanotechnology - Charles P Poole Jr, Frank J Owens

Reference Books

1. Handbook of Semiconductor Nanostructures and Nanodevices Vol 1-5 - A. A. Balandin, K. L. Wang.

2. From Atom to Transistor-SupriyoDatta

3. Quantum Hetero-structures: Micro-electronics and opto-electronics, VV Mitin, VA Kochelap, MA Stroscio.

MICRO/NANOFLUIDICS - DESIGN & MODELLING

Module I (8 hours)

Physics of fluids at the micrometer and nanometer scale, laminar flow, fabrication of microfluidics and nanofluidic devices, applications of nanofluidics for bionanotechnology.

Module II (12 hours)

Micro/nanofluidic computing, Micro-fluidic system assembly. Fundamental aspects of fluid mechanics, scaling laws, flow transport at small length scales. Capillary-driven, pressure-driven, and electro-kinetic based microfluidics, multi-phase flow, droplet-based microfluidics and complex fluids flow, micro-mixing and pumping systems and cell based microfluidics.

Module III (10 hours)

Nanofluidics and surfaces: liquid structure near solid-liquid interfaces: simple liquids; layering electrolytes: Poisson-Boltzmann equation; Debye Hückel approx., nanofluidic transistors, nanofluidic memory.

Module IV (12 hours)

Hydrodynamics at small scales (laminar flow, slip versus no-slip, mixing), electro kinetic effects, solid-liquid interfaces (interactions, adsorption/desorption), 3-phase systems (capillary forces, wetting, superhydrophobicity), electrokinetic effects (electroosmotic pumping, electroviscous effect), electrophoresis and separation techniques, colloids, surface reconstruction, dangling bonds and surface states.

Text Books

1. Nanotechnology Understanding Small Systems, Rogers Pennathur Adams, CRC Press, Taylor & Francis Group.
2. Fundamentals and Applications of Microfluidics by Nam-Trung Nguyen and Steve Wereley

Reference Books

1. Introduction to Solid State Physics : Kittel
2. Introduction to Theory of Solids : H.M. Rosenberg
3. Theoretical Microfluidics by Henrik Bruus, Oxford
4. Introduction to Microfluidics by Tabeling, Oxford
5. Microdrops and digital microfluidics by Jean Berthier
6. The Structure and Rheology of Complex Fluids by R. Larson

NANOPOLYMERS IN MEDICINE

Module I (10 hours)
Bionanotechnology today: Basic capabilities, Functional principles of Bionanotechnology: Information driven nano-assembly, Energetics, Chemical transformation, Regulation, Biomaterials, Biomolecular motors, Traffic across membranes, Biomolecular sensing, Self replication, Machine-Phase bionanotechnology.

Module II (10 hours)
Nanomedicine, Molecular design using biological selection, Harnessing molecular motors, Artificial life, Hybrid materials, Biosensors. Structural principles of Bionanotechnology: The raw materials; biomolecular structure and stability, Protein folding, Self assembly, Self-organization, Molecular recognition, Flexibility

Module III (12 hours)
Biomaterial based metallic nanowires, networks and circuitry: DNA as functional template for nanocircuitry; Protein based nanocircuitry; Neurons for network formation. DNA based nanomechanical devices. Biosensor and Biochips. Drug Delivery, Therapeutic action of nanoparticles and nanodevices- Targeted, non-targeted delivery; controlled drug release; exploiting novel delivery routes using nanoparticles; gene therapy using nanoparticles;

Module IV (12 hours)
Nanostructures for use as antibiotics, diseased tissue destruction using nanoparticles; diagnostics using nanomaterial, nanoparticles for bioanalytical applications - nanodevices for sensing and therapy. Use of nanoparticles for MRI, X Ray, Ultrasonography, Gamma ray imaging. Nanoparticles as molecular labels; biological labeling using quantum dots as molecular labels; Tissue Engineering.

Text Books

1. Nanotechnology Understanding Small Systems, Rogers Pennathur Adams, CRC Press, Taylor & Francis Group.
2. Gonsalves; Kenneth E., Halberstadt; Craig R., Laurencin; Cato T. And Nair; Lakshmi S.(Eds.), Biomedical Nanostructures, Wiley-Interscience, Hoboken (2008).
3. Chu; Paul K. and Liu; Xuanyong (Eds.), Biomaterials Fabrication and Processing Handbook, CRC Press, Boca Raton (2008)
4. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology - Hari Singh Nalwa

Reference Books

1. Bionanotechnology: Lessons from Nature by David S. Goodsell
2. Nanocomposite Science & Technology Ajayan, Schadler& Braun
3. BioMEMS (Microsystems) - Gerald A. Urban
4. Nanosystems: Molecular Machinery, Manufacturing, &Computation - K. Eric Drexler
5. Nanobiotechnology; ed. C.M.Niemeyer, C.A. Mirkin.
6. Nanofabrication towards biomedical application: Techniques, tools, Application and impact – Ed. Challa S., S. R. Kumar, J. H. Carola.
7. Dendrimers I, II, III, Ed. F. Vogtle
8. Tissue Engineering-Bernhard O. Palsson , Sangeeta N. Bhatia
9. Principles of Tissue Engineering - Robert Lanza, Robert Langer, & Joseph P

TECHNOLOGY, INNOVATION AND QUALITY MANAGEMENT

Module I (8 hours)

Understanding Management of Technology, innovation technology evaluation, Diffusion. Technology and competition, Integration of strategic planning and technology planning.

Module II (10 hours)

Technology Strategy: Technology intelligence – collaborative mode, Appropriation of technology – Technology evaluation and financing – changing role of R & D, Management of manufacturing technology – corporate cultures – technology audits.

Module III (10 hours)

Introduction to quality – basic concepts, definition, quality of design and conformance, quality circle, ISO 9000 & their documentation. Data collection and presentation – SQC techniques & their applications, presentation of data, frequency distributions and pie diagram.

Module IV (12 hours)

Measures of central tendency & dispersion – calculation of mean, median, mode, standard deviation & variance, concept of distribution, introduction to tests to simple hypothecs. Inspection, sampling & correlation analysis.

References:

1. Babcock D.L. “Managing Engineering Technology” Prentice Hall.
2. Burgelman et.al “Strategic Management of Technology and Innovation” Tata McGraw Hill (2001).
3. Cleland and Bursic “Strategic Technology management” Amacom, Newyork.
4. Narayanan U.K. “Managing Technology and Innovation for competitive Advantage” Pearson Education, Asia 2001.
5. Betz F “Managing Technology – competing Through New Ventures, Innovation and Corporate Research.” Prentice Hall.
6. B. L Agarwal, Basic Statistics, Wiley Eastern Limited, II Chapter
7. Suddhendu Biswas, Statistics of Quality Control, Wiley Eastern Limited, 2008
8. Juran&Geyna, Modern Methods for Quality Control and Improvement, John Wiley & Sons 1986

MECHANICS OF FINITE SIZE ELEMENTS

Module I (10 hours)

Introduction to Finite Element Method: Engineering Analysis, History, Advantages, Classification, Basic steps, Convergence criteria, Role of finite element analysis in computer-aided design., Mathematical Preliminaries, Differential equations formulations, Variational formulations, weighted residual methods.

Module II (12 hours)

One-Dimensional Elements - Analysis of Bars and Trusses: Basic Equations and Potential Energy Functional, 1-0 Bar Element, Admissible displacement function, Strain matrix, Stress recovery, Element equations, Stiffness matrix, Consistent nodal force vector: Body force, Initial strain, Assembly Procedure, Boundary and Constraint Conditions, Single point constraint, Multi-point constraint, 2-D Bar Element, Shape functions for Higher Order Elements

Module III (12 hours)

Two-Dimensional Elements - Analysis of Plane Elasticity Problems: Three-Noded Triangular Element (TRIA 3), Four-Noded Quadrilateral Element (QUAD 4), Shape functions for Higher Order Elements (TRIA 6, QUAD 8), Axi-symmetric Solid Elements-Analysis of Bodies of Revolution under axi-symmetric loading: Axisymmetric Triangular and Quadrilateral Ring Elements. Shape functions for Higher Order Elements

Module IV (12 hours)

Three-Dimensional Elements - Applications to Solid Mechanics Problems: Basic Equations and Potential Energy Functional, Four-Noded Tetrahedral Element (TET 4), Eight-Noded Hexahedral Element (HEXA 8), Tetrahedral elements, Hexahedral elements: Serendipity family, Hexahedral elements: Lagrange family. Shape functions for Higher Order Elements

References:

1. Chandrupatla T. R.,"Finite Elements in engineering"- 2nd Edition, PHI, 2007.

2. Lakshminarayana H. V.,"Finite Elements Analysis"– Procedures in Engineering, Universities Press, 2004

3. Rao S. S. "Finite Elements Method in Engineering"- 4th Edition, Elsevier, 2006.

4. P.Seshu, "Textbook of Finite Element Analysis" -PHI, 2004.

5. J.N.Reddy, "Finite Element Method"- McGraw -Hill International Edition.

6. Bathe K. J. "Finite Elements Procedures"- PHI.

7. Cook R. D., et al., "Concepts and Application of Finite Elements Analysis"- 4th Edition, Wiley & Sons, 2003.

GREEN NANOTECHNOLOGY

Module I

Introduction to nanomaterials:
Nanoparticles preparation techniques, Greener Nanosynthesis:
Greener Synthetic Methods for Functionalized Metal Nanoparticles, Greener Preparations of Semiconductor and Inorganic Oxide Nanoparticles, green synthesis of Metal nanoparticles, Nanoparticle characterization methods,

Module II

Nanomaterials for "Green" Systems:
Green materials, including biomaterials, biopolymers,
bioplastics, and composites Nanotech Materials for Truly Sustainable Construction: Windows,
Skylights, and Lighting. Paints, Roofs, Walls, and Cooling. Multifunctional Gas Sensors, Biomimetic
Sensors, Optical Interference Sensors Thermo-, light-, and stimulus-responsive smart materials Nanomaterials

Module III

Nanomaterials for Alternative Energy:
Nanomaterials for Fuel Cells and Hydrogen
Generation and storage, Nanostrcutures for efficient solar hydrogen production, Metal Nanoclusters in Hydrogen Storage Applications, Metal Nanoparticles as Electrocatalysts in Fuel
Cells, Nanowires as Hydrogen Sensors, Ceramic nanocomposites for alternate energy and environment protection, Applications for Cobalt Nanoparticles and Graphite Carbon-Shells, Nanomaterials for Solar Thermal Energy and Photovoltaic. Semiconductor Nanocrystals and Quantum Dots for Solar Energy Applications Nanoparticles for Conducting Heat Transfer

Module IV

Nanomaterials in Energy Storage Devices:
MWNT for Li Ion Batteries, Nanomaterials in
Electrodes, Hybrid Nanotubes: Anode Material, Supercapacitor, Battery Electrodes
Metal nanocluster catalysts for Coal Liquefaction. Nanomaterials for Desalination and Purification of Water.

Reference:

[1] Nanotechnology for Photovoltaics, by Loucas Tsakalakos, ISBN:9781420076745, Publisher: CRC Press, Publication Date: April 2010.
[2] Dahl, 1. A.; Maddux, B. L. S.; Hutchison, 1. E. Toward Greener Nanosynthesis. Chemical Reviews, 2007, 107,
2228-2269.
[2] Nanomaterials, nanotechnologies and design: an introduction for engineers By M. F. Ashby, Daniel L. Schodek,
Paulo J. S. G. Ferr
[3] Nanoscale materials By Luis M. Liz-Marzán, Prashant V. Kamat
[4] Environmental applications of nanomaterials: synthesis, sorbents and sensors By Glen E. Fryxell, Guozhong Cao
[8]. Global roadmap for ceramics and glass technology By Mrityunjay Singh, Gary S. Fischman, Stephen Freiman,
John Hellmann, Kathryn Logan, Tom Coyle, Wiley 2007
[9] On Solar Hydrogen and Nanotechnology By Lionel Vayssieres Wiley, 2009
[10] Green Nanotechnology: Solutions for Sustainability and Energy in the Built Environment
[11] Geoffrey B. Smith, University of Technology, Broadway, Australia; Claes-Goran S. Granqvist, Uppsala University, Sweden CRC Press ISBN: 9781420085327, Publication Date: August 31, 2010.