BIJU PATNAIK UNIVERSITY OF TECHNOLOGY, ODISHA
ROURKELA

M.Tech (NANOTECHNOLOGY)

SEMESTER- I

(Applicable to the students admitted from the Academic year 2012 – 2013 onwards)

Code No.	Course Title	L	T	P	Credit
THEORY					
	Professional Core				
NTPC101	Physics and Chemistry of Nanomaterials	3	1	0	4
NTPC102	Synthesis and Applications of Nanomaterials	3	1	0	4
NTPC103	Elements of Material Science and properties of Nanomaterials	3	1	0	4
	Professional Electives -I (Any one)				
NTPE101	Nanoparticles and Microorganisms, Bionanocomposites	3	1	0	3
NTPE102	Quantum Mechanics	3	1	0	3
NTPE103	Biological System	3	1	0	3
	Professional Electives –II (Any one)				
NTPE104	Mechanical Processing and properties of Nanostructure Materials.	3	1	0	3
NTPE105	Physicochemical methods for characterization of Nanomaterials.	3	1	0	3
NTPE106	Nanotechnology in Health care.	3	1	0	3
Sessional / Practical					
NTPR101	Engineering Software Laboratory	0	0	3	2
NTPR102	Synthesis of Nanomaterials Laboratory	0	0	3	2
NTPT101	Pre-Thesis work and Seminar				2
					Total Credit -24

SEMESTER- II

Theory		**Contact Hours**	
	Professional Core	**L-T-P**	**Credit**
NTPC201	Mathematical modeling and simulation	3-1-0	4
NTPC202	Fabrication techniques and charactersisation of Nanomaterials.	3-1-0	4
	Professional Electives- III(Any One)		
NTPE201	Nanocomposites	3-0-0	3
NTPE202	Advance Nanomaterials.	3-0-0	3
NTPE203	Computational Nanoscience	3-0-0	3
	Professional Electives- IV(Any One)		
NTPE204	Product design. Management Techniques and Entrepreneurship.	3-0-0	3
NTPE205	Nanotechnology for Energy systems.	3-0-0	3
NTPE206	MEMS and Bio MEMS.	3-0-0	3
	Professional Electives- V(Any One)		
NTPE207	Biosensors.	3-0-0	3
NTPE208	Biophotonics.	3-0-0	3
NTPE209	Semiconductor nanostructures and nanoparticles.	3-0-0	3
Practical/ Sessionals		**Contact Hours**	
	Professional Core	**L-T-P**	**Credit**
NTPR201	Laboratory – II	0-0-4	4
NTPT201	Pre-thesis work and Seminar	0-0-3	2
NTCV201	Comprehensive Viva – Voce- I	0-0-3	2
		Total	**25**

NTPC101 PHYSICS AND CHEMISTRY OF NANOMATERIALS

Unit-I PHYSICAL PROPERTIES: Melting point and phase transition process- quantum-size-effect (QSE). Size-induced metal-insulator-transition (SIMIT)- nano-scale magnets, transparent magnetic materials, and ultrahigh-density magnetic recording materials-chemical physics of atomic and molecular clusters.

PHYSICAL CHEMISTRY OF SOLID SURFACES: Surface energy – chemical potential as a function of surface curvature-Electrostatic stabilization- surface charge density-electric potential at the proximity of solid surface-Van der Waals attraction potential.

Unit-II CHEMISTRY ASPECTS: Photochemistry; photoconductivity; Electrochemistry of Nanomaterials-Diffusion in Nanomaterials; Nanoscale Heat Transfer; Catalysis by gGold Nanoparticles; Transport in Semiconductor Nanostructures; Transition Metal Atoms on Nanocarbon Surfaces; Nanodeposition of Soft Materials; Nanocatalysis.

Unit –III NANOSTRUCTURES: Electronic Structure of Nanoparticles- Kinetics in Nanostructured Materials-Zero dimensional, one-dimensional and two dimensional nanostructures- clusters of metals and semiconductors, nanowires, nanostructured beams, and nanocomposites- artificial atomic clusters-Size dependent properties-size dependent absorption spectra-phonons in nanostructures.

Unit-IV NANOSYSTEMS: Nanoparticles through homogeneous nucleation-Growth controlled by diffusion-growth controlled by surface process-influences lof reduction reagents- Solid state phase segregation-kinetically confined synthesis of nanoparticles-template based synthesis.

References:

1) K.W. Kolasinski, “Surface Science: Foundations of Catalysis and Nanoscience”, Wiley, 2002.
2) Joel I. Gersten, “The Physics and Chemistry of Materials”, Wiley, 2001.
3) A.S. Edelstein and R. C. Cammarata, “Nanomaterials: Synthesis, Properties and Applications”, Institute of Physics Pub., 1998.
4) S.Yang and P.Shen: “Physics and Chemistry of Nanostructured Materials”, Taylor & Francis, 2000.
5) G.A. Ozin and A.C. Arsenault, “Nanochemistry : A chemical approach to nanomaterials”, Royal Society of Chemistry, 2005.

NTPC102 SYNTHESIS AND APPLICATIONS OF NANOMATERIALS

UNIT-I BULK SYNTHESIS: Synthesis of bulk nano-structured materials –sol gel processing –Mechanical alloying and mechanical milling- Inert gas condensation technique – Nanopolymers – Bulk and nano composite materials.

UNIT-II CHEMICAL APPROACHES: Self-assembly, self-assembled monolayers (SAMs). Langmuir-Blodgett (LB) films, clusters, colloids, zeolites, organic block copolymers, emulsion polymerization, templated synthesis, and confined nucleation and/or growth. Biomimetic Approaches: polymer matrix isolation, and surface-templated nucleation and/or crystallization. Electrochemical Approaches: anodic oxidation of alumina films, porous silicon, and pulsed electrochemical deposition.

UNIT-III PHYSICAL APPROACHES: Vapor deposition and different types of epitaxial growth techniques-pulsed laser deposition, Magnetron sputtering - Micro lithography (photolithography, soft lithography, micromachining, e-beam writing, and scanning probe patterning).

UNIT-IV NANOPOROUS MATERIALS: Nanoporous Materials – Silicon - Zeolites, mesoporous materials - nanomembranes and carbon nanotubes - AgX photography, smart sunglasses, and transparent conducting oxides –molecular sieves – nanosponges.

APPLICATION OF NANOMATERIALS: Molecular Electronics and Nanoelectronics – Nanobots- Biological Applications – Quantum Devices – Nanomechanics - Carbon Nanotube – Photonics- Nano structures as single electron transistor –principle and design.

Reference:

1. S.P. Gaponenko, Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.
2. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate(Eds.), Handbook of NanoScience, Engg. and Technology, CRC Press, 2002.
3. K. Barriham, D.D. Vvedensky, Low dimensional semiconductor structures: fundamental and device applications, Cambridge University Press, 2001.
4. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties &Applications , Imperial College Press, 2004.
5. J.George, Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005.

NTPC103 ELEMENTS OF MATERIAL SCIENCE AND PROPERTIES OF NANOMATERIALS

Unit-I Solid State Physics (Overview): Amorphous, crystalline, crystals, polycrystals, symmetry, Unit Cells, Crystal Structures (Bravais Lattices), , Crystallographic Directions, Crystallographic Planes, Miller Indices, Bragg's Law, X-ray Diffraction.

Imperfections of crystal structure: point defects, Grain boundaries, phase boundaries, Dislocations Screw, Edge and Mixed Dislocations generation of defects by quenching, by plastic deformation and by radiation, interaction between point defects and dislocations

Unit-II Electronic Properties, Classification of materials: Metal, Semiconductor, Insulator, Band structures, Brillouin zones, Mobility, Resistivity, Relaxation time, Recombination centers, Hall effects.

Unit –III Confinement and transport in nanostructure, Current, reservoirs, and electron channels, conductance formula for nanostructures, quantized conductance. Local density of states. Ballistic transport, Coulomb blockade, Diffusive transport, Fock space.

Dielectric properties: Polarisation, Ferroelectric behaviour.

Unit-IV Optical Properties, Photoconductivity, Optical absorption & transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence.

References:

1. Introduction to Solid State Physics -C. Kittel
2. Solid State Physics- A.J. Dekker
3. Solid State Physics -R.K Puri and V.K.Babar
4. The Physics and Chemistry of Solids - Stephen Elliott & S. R. Elliott
5. Scanning Probe Microscopy: Analytical Methods (NanoScience and Technology)- Roland Wiesendanger
6. Advanced X-ray Techniques in Research and Industries - A. K. Singh (Editor)
7. X-Ray Diffraction Procedures: For Polycrystalline and Amorphous Materials, 2nd Ed.- Harold P. Klug, Leroy E. Alexander
8. Transmission Electron Microscopy: A Textbook for Materials Science (4-Vol Set)- David B. Williams & C. Barry Carter
9. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM - Ray F. Egerton
10. Structures and Properties of Solid State Materials – B. Viswanathan.
11. Basic Solid State Chemistry – Anthony R. West.

NTPE101 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 bioelectronic biorecognition 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

NTPE102 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, Quntum Qbits 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

NTPE103 BIOLOGICAL SYSTEMS

UNIT-I INTRODUCTION TO DNA STRUCTURE: DNA double helix, genome structure and organization in prokaryotes and eukaryotes, Central dogma DNA is a genetic material-Experiments, DNA replication-Mechanism of replication, different types in prokaryotes and eukaryotes, Enzymes involved and its details, Mechanism of transcription in prokaryotes and eukaryotes, splicing and transcriptional factors, transcriptional inhibitors, mechanism of translation, translational factors, Prokaryotic and eukaryotic translation machinery, Co and post translational modifications.

UNIT-II INTRODUCTION TO AMINO ACIDS AND PROTEINS: Physical and chemical properties of amino acids, different types of protein, Proteins of pharmaceutical importance, role of covalent and non covalent interactions important to protein structure and functions.

UNIT-III PROTEIN STRUCTURE: Primary, secondary, super secondary, tertiary, quaternary structures and the methods to determine, including prediction methods and utilization of genomic databases.
LIPIDS AND CARBOHYDRATES: Structure – function – biosynthesis – Metabolism.

UNIT-IV CELL STRUCTURE AND FUNCTION OF ORGANELLES: Eukaryotic and Prokaryotic cells, Principle of membrane organization, cytoskeletal proteins, types of cell division, mitosis and meiosis, cell cycle and molecules that control cell cycle, structural organization and multiplication of bacteria, viruses, algae and fungi.

References:

1. R. Cantor, P.R.Samuel, “Biophysical Chemistry”, W.H., Freeman & Co., 1985.
2. Watson, James, T.Baker, S.Bell, A.Gann, M.Levine, and R.Losick. “Molecular Biology of the Gene”, 5th ed., San Francisco: Addison-Wesley, 2000.
3. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. Molecular Biology of the Cell. 4th ed. New York: Garland Science, 2002.
4. Branden, Carl-Ivar, and John Tooze. Introduction to Protein Structure. 2nd ed. New York: Garland Pub., 1991.
5. Creighton, E, Thomas, “Proteins: Structures and Molecular Properties”, 2nd Ed. New York: W.H. Freeman, 1992.
6. B.Lewin, “Genes IX”, International Edition. Sudbury: Jones & Bartlett, 2007.

NTPE104 MECHANICAL PROCESSING AND PROPERTIES OF NANOSTRUCTURED MATERIALS

UNIT-I PROCESSING OF METALS AND ALLOYS: Understanding the following processes from the viewpoints of mechanics and processes: rolling, forging, extrusion, wire drawing, sheet metal forming.
PROCESSING OF POLYMERS: Special techniques like injection moulding, thermoforming, vacuum and pressure assisted forming.

UNIT-II PROCESSING OF POWDERS OF METALS AND CERAMICS: Selection and characterization of powders, compacting and sintering; mechanical working. Production of Porous and Dense Composite Components: Metal- polymer- and ceramic- based composites.

UNIT-III PROCESSING OF STRUCTURAL AND FUNCTIONAL NANOCRYSTALLINE MATERIALS: Properties required of nanocrystalline materials used for structural, hydrogen storage, magnetic and catalytic applications; processing techniques; techniques for retaining the nanocrystalline structure in service.

UNIT-IV MICROSTRUCTURE AND PROPERTIES: Properties slightly dependent on temperature and grain size; properties strongly dependent on temperature and grain size; strengthening mechanisms; enhancement of available plasticity; grain size evolution and grain size control; Hall-Petch relation, microstructure – dislocation interactions at low and high temperatures; effects of diffusion on strength and flow of materials; methods of enhancing or retarding diffusion; grain boundary sliding and grain boundary migration; current limitations on approaches based on dislocation theory; possibilities for predictive design.

References:

1. A. H. Cottrell “The Mechanical Properties of Matter”, John Wiley, New York- London, 1964.
2. P. Haasen, “Physical Metallurgy”, Cambridge University Press, Cambridge, UK, 1978.
3. G. E. Dieter, adapted by D Bacon, “Mechanical Metallurgy”, SI Metric edition, MaGraw-Hill, Singapore, 1988.
4. K. A. Padmanabhan, “Mechanical Properties of Nanostructured Materials”, Materials Science and Engineering, A 304-306 (2001) 200-205.
5. C. C. Koch, “Nanostructured Materials: Processing, Properties and Applications”, 2nd Edition, Ed.: 2007.

NTPE105 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.

NTPE106 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

Laboratory-I

Section A

1. To study kinetics of hydrolysis of an ester.

2. Effect of surfactant concentration on equivalent conductance and determination of critical micelle concentration (CMC).

3. Verification of Lambert Beer's law and determination of concentration of unknown solution by UV-Vis spectrophotometer.

4. Preparation of colloidal Silver (Ag) nanoparticles with trisodium citrate and their characterization by UV-Vis spectroscopy.

5. To study Hydrogen bonding by FT-IR spectroscopy

6. Preparation of metal oxide nanoparticles by microemulsion technique.

7. Characterization of prepared metal oxide nanoparticles by XRD and determination of their size by Scherrer's Equation.

Section B

1. To determine the Band-Gap of given Semiconductor Using Four Probe Method from Liquid Nitrogen Temp to Room Temperature

2. To determine the Band-Gap of given Semiconductor Using Four Probe Method From Room Temperature to 100 C

3. Synthesis of at least two different sizes of Nickel Oxide Nano Particles Using Sol-Gel Method

4. Synthesis of at least two different sizes of Copper Oxide Nano Particles Using Sol-Gel Method

5. Synthesis of at least two different sizes of Zinc Oxide Nano Particles Using Sol-Gel Method

6. Determine the Radius of Curvature of Lens using Newton's Ring Method

7. Determine the wavelength of given Laser , estimate the slit width using Laser

8. Calculate the diameter of given thin wire using Laser.

SECOND SEMESTER

NTPC201 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. Enwin Kreyzig,"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.

NTPC202 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 Oprical Microsope 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;Alexei Bogdanov;Simon Wingar; 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)

NTPE201 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 diblock Coplymer 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. Iijima, 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

NTPE202 ADVANCED NANOMATERIALS

Unit – I Fundamentals of magnetic materials, Dia, Para , Ferro , Antiferro , Ferri, Superpara magnatic 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. Nocel Nanocrustalline 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 A Govindraj RCS Publishing.
11. CRC Handbook of Thermoelectrics, Ed. CR Rowe

NTPE203 COMPUTATIONAL NANOSCIENCE

Unit – I Introduction to Matlab and Mathematics (and open source counterparts- Scilab and Octave); example from nano- optics and nano – electronics.

Unit – II Monte Carlo Similations; Computational methods and Simulations from ab initio to miltiscale Modeling.

Unit- III Molecular dynamics, computing and simulations.

Unit – IV Nanodesign Nano-CAD , Modeling of Nanodvices. Applications and examples problems based on Molecular dynamics simulations.

Reference

1. Introduction to Computer simulation methods. Gould, Tobochink et al(Addition weekly-2006)

NTPE204 PRODUCTION DESIGN, MANAGEMENT TECHINQUES AND ENTERPERENCEURSHIP

Unit – I PRODUCT DESIGN: Concept generation – product Architecture- Industrial Design Process- Management of Industrial design Process and Assessing the quality of Industrial Design –Establishing the product specification

PRODUCT DEVELOPMENT:Criteria for selection of product- Product development process- design for Manutacture –Estimate the manufacturing cost- Reduce the support cost- Prototyping –Economics of Product development projects – Elements of Economic analysis – fincancial models – Sensitive analysis and influence of the quantitative factors.

Unit – II MANAGEMENT TECHNIQUES: Technology Management – Scientific Management – Development of management Thought-Principles of Management – Functions of Management planning – organization Enterprise Resource planning and supply chain management.

Unit – III ENTERPRENEURIAL COMETENCE & ENVIRONMENT: Concept of Entrepreneurship – Enterpreneurship as a career- Personality Characterstic a successful Enterpreneur – Knowledge and skill required for Enterpreneur- Business environment – Enterpreneurship Development Training – Canter and State government plicies and Tegulations –International Business.

Unit-IV MANAGEMENT OF SMALL BUSINESS: Pre feasibility study – Ownership- budgeting – project profile preparation – Feasibility Report preparation – Evvaluation of Business – Effective Management of Small business.

References:

1. Karal, T. Ulrich Steven, D. Eppinger,"Product Design and Development", McGraw- Hill International, editions, 2003.
2. S.Rosenthal, "Effective Product Design and Development" Irwin, 1992.
3. H.Koontz and H. Weihrich, "Essentials of management", McGraw Hill Publishing company , Singapore international edition, 1980.
4. J.J. Massie, "Essentials of Management" Prentice Hall of India Pvt. Ltd., 1985.
5. Hisrich, "Enterpreneurship" Tata McGrew Hill, New Delhi, 2001

NTPE205 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.

NTPE206 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, Xiaoning jiang, and Vasundara Varandan, 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. Wiegeringk Miko Elwenspoek, Mechanical Microsensors (Microtechology and MEMS), Springer Verlag 2001.

NTPE207 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 zymo Biosensors .

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.K Knoff , A.S Bassi, CRC Press, 2006

NTPE208 BIOPHOTONICS

Unit –I Interaction of light with cells , tissues , non-linier optical process with intense laser beams, photo-induced effects I biological systems.

Imaging techniques: Light microscopy, wide-field, laser scanning, confocal, multiphoton, fluorescence lifetime imaging, FRET imaging, Frequency-Domain lifetime imaging. Cellular Imaging, Imaging of soft and hard tissues and other biological structures.

Unit – II Single molecule spectroscopy: UV-VIS spectroscopy of biological systems, single molecule spectra and characteristics – IR and Raman Spectroscopy and Surface Enhanced Raman Spectoscopy for single molecule applications.

Unit- III Optical Force Spercroscopy: Generation optical forces – Optical trapping and manipulation for bio single molecules and cells in optical confinement – Laser trapping and dissection for biological systems – single molecule biophysics, DNA protein interactions .

Unit – IV Biosensors, fluorescence immunoassay, flow cytometry, Fluorescence correlation spectroscopy, Fluorescence correlation spectroscopy, Fluorophores as Cellular and molecular tags.

Reference:

1. Laser Tweezers in Cell Biology in Methods in Cell Biology, Vol. 55, Michael P. Sheetz (Ed.) Academic Press.
2. P.N Prasad, Introduction to Biophotonics, John- Wiley,2003.
3. G. Marriot &I.Parker, Methods in Enzymology,Vol 360,2003.
4. G. Marriot & I. Parker, Methods In Enzymology, Vol.361,2003.

NTPE209 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

Laboratory – II,

COMPUTATION LABORATORY AND SIMULATION

SEC-A

1. MATLAB programme to plot the first four eigenfunctions of a one - dimensional rectangular potential well with infinite potential barrier.
2. Numerical solution of the Schrodinger wave equation for a rectangular potential well with infinite potential barrier using MATLAB programme.
3. Toy model in molecular electronics: IV characteristics of a single level molecule
4. To determine the lattice constant and lattice angles for atomically resolved STM image of HOPG (Highly Oriented Pyrolytic Graphite using offline Scanning Probe Imaging Processor (SPIP) Software.
5. To determine the surface roughness of raw and processed AFM images of glass, silicon and films made by different methods using offline SPIP software.
6. Simulation of I-V Characteristics for a single Junction circuit with a single quantum Dot using MOSES 1.2 Simulator.
7. Study of Single Electron Transistor using MOSES1.2 Simulator.

MATERIAL SYNTHESIS AND EXPERIMENTS

SEC-B

1. Chemical synthesis of Ag nanoparticles; UV-Visible absorption of the colloidal sol; Mie formalism; Estimation of size by curve fitting

2. Chemical synthesis of CdS nanoparticles; Optical absorption spectra; Band gap estimation from the band edge

3. Aqueous to organic phase transfer of Ag and CdS nanoparticles; Confirmation by UV- Visible absorption

4. Synthesis of Au and Ag nanoparticles at aqueous-organic liquid interface; UV- visible spectroscopy of the colloidal film; comparison with the corresponding colloidal sol.

5. Sol gel synthesis of ZnO nanoparticles

6. Micellar route to Pt nanoparticles

7. A bioroute to Au nanoparticles

8. Room temperature B-H loops for α-Fe_2O_3 nanoparticals of different sizes (5-50 nm.)