SCHEME OF EXAMINATION

&

SYLLABUS for M.Tech.

in

Nano Science & Technology

Implemented from August 2008

UNIVERSITY SCHOOL OF BASIC & APPLIED SCIENCES

GGS INDRAPRASTHA UNIVERSITY

KASHMERE GATE

DELHI – 110403

Approved in 27th meeting of the academic council held on 15-06-2009. Agenda Item No. 27.9

Outline of the course

- **Duration** **:** 2 Years (4 semesters)

- **Total Credits** **:** 105 (Minimum required for the degree:100 Credits)
- **Admission Criterion :** GATE Score *
- **Number of Seats** **:** 15
- **Eligibility:**
  - M. Sc. (Physics / Applied Physics / Electronics /Mathematics / Chemistry /Biotechnology /Biosciences /Life Sciences);
  - BE / B.Tech (Electronics /Computer Science /Electrical /Mechanical /Engineering Physics / Metallurgy /Material Engg. /Information Technology /Biotechnology /Chemical Engg. or Technology)
  - Minimum 55% aggregate marks and Mathematics at +2 level is a must.

Scheme of Examination for M.Tech Nano Science & Technology

Semester - I Credits: 27

S. No.	Course Code	Title of the course	Credits	Remarks L/T/P
1.	NST-101	Elements of Physics	4	4/0/0
2.	NST-103	Elements of Physical Chemistry	4	4/0/0
3.	NST-105	Nanoparticles and Microorganisms, Bionanocomposites	3	3/0/0
4.	NST-107	Elements of Material Science and properties of Nanomaterials	4	4/0/0
5.	NST-109	Nanotechnology & Society	1	1/0/0 (NUES)
6.	NST-111	Basic Mathematics / Life Sciences	2	2/0/0
7.	NST-151	Laboratory-I	6	0/0/12
8.	NST-153	Self Study-I	3	0/3/0

L = Lecture, T = Tutorial, P = Practical

NUES => Non University Examination System

w.e.f. August 2008 **DEAN : USBAS**

Semester - II Credits: 29

S. No.	Course Code	Title of the course	Credits	Remarks L/T/P
1.	NST-102	Fabrication techniques and Characterisation of Nanomaterials	4	4/0/0
2.	NST-104	Soft Synthetic Routes & Some Novel Nanomaterials	4	4/0/0
3.	NST-106	Nanodevices & Nanosensors	4	4/0/0
4.	NST-108	Scientific Computation & Simulation	1	1/0/0 (NUES)
5.	NST-110	Solutions & Surface Phenomenon	4	4/0/0
6.	NST-112	Business Enterprise in Nanotechnology & Project Management	1	1/0/0 (NUES)
7.	NST-152	Laboratory-II	6	0/0/12
8.	NST-154	Self Study-II	3	0/3/0
9.	NST-156	Scientific Computation & Simulation	2	0/0/4

NUES => Non University Examination System

The students will proceed for summer training at the end of second semester for a period of 6-8 weeks. They will submit the training report after its completion to the program coordinator.

w.e.f. January 2009

Semester - III Credit: 24

S. No.	Course Code	Title of the course	Credit /wk	Remarks L/T/P
1.	NST-201	Advanced Nanomaterials	3	3/0/0
2.	NST-203	Semiconductor nanostructures and nanoparticles	3	3/0/0
3	**Electives (any 2)**			
	NST-205	Molecular Nanoelectronics	3	3/0/0
	NST-207	Photonics & Plasmonics	3	3/0/0
	NST-209	Carbon Nanotubes & Functionalisation	3	3/0/0
	NST-211	Computational Nanoscience	3	3/0/0
4	NST- 213	IPR & Nanotechnology	1	1/0/0 (NUES)
5	NST-251	Self Study-III	2	0/2/0
6	NST-253	Minor Project	5	**
7.	NST-255	Summer training (Viva-voce)	4	**

NUES => Non University Examination System

w.e.f. August 2008 **DEAN : USBAS**

Semester - IV Credit: 25

S. NO.	Course Code	Title of the course	Credit /wk	Remarks
1.	NST-202	Project Work /Internship (Seminar)	20	**
2.	NST-204	Comprehensive Viva Voce	5	NUES

NUES => Non University Examination System

Total Credits: 105

Credits Required for the Degree: 100

w.e.f. August 2008 **DEAN : USBAS**

Detailed Syllabi

Semester-I

Course Code: NST-101 **Title: Elements of Physics**
L/T/P: 4/0/0

Unit-I: Introduction to Quantum Mechanics: Wave-particle duality, Schrödinger equation and expectation values, Uncertainty principle. Solutions of the one-dimensional Schrodinger 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 at higher dimensions and more complicated systems Particle in a three dimensional box, linear harmonic oscillator and its solution, density of states, free electron theory of metals. The angular momentum 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: Statistical Mechanics, Microstates and entropy and its statistical definition, Entropy of mixing, Gibb's free energy, Gibb's paradox, phase space density, ergodic hypothesis, Liouville's theorem, The microcanonical-, canonical- and grand canonical- ensemble and their connections, Fluctuations. Classical Statistical systems, Boltzman statistics Liouville's theorem, The microcanonical-, canonical- and grand canonical- ensemble and their connections, Fluctuations. Classical Statistical systems, Boltzman statistics and quantum statistical systems, Fermi-Dirac and Bose-Einstein Statistics and their applications (An overview).

References: (NST 101)

1. Quantum Physics – A. Ghatak
2. Quantum Mechanics-Mc Quarie
3. Quantum Mechanics - Bransden and Joachen
4. Quantum Mechanics - Vol 1&2 - Cohen-Tannoudji
5. Quantum wells, Wires & Dots,: Theoretical & Computational Physics of Semiconductors Nano-stuructures, Paul Harrison
6. Quantum Hetero-structures: Micro-electronics and opto-electronics, VV Mitin, VA Kochelap, MA Stroscio.
7. Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, 2nd Edition by Eisberg, Robert; Resnick, Robert
8. Principles of Quantum Mechanics 2nd ed. - R. Shankar
9. Thermodynamics and Statistical Mechanics - A N Tikhonov, Peter T Landberg, Peter Theodore Landsberg
10. Thermodynamics and Statistical Mechanics by John M. Seddon , J. D. Gale
11. Statistical Physics by K. Huang
12. Statistical Mechanics-Landau &Lifshitz
13. Statistical Mechanics – Sonntag.
14. Statistical Mechanics – Mc Le Leland

Course Code: NST-103 **Title: Elements of Physical Chemistry**
L/T/P: 4/0/0

.**Unit I-** Chemical Bonding: Atomic Bonding in solids, Types of bond: Metallic, Ionic, Covalent and vanderwaals bond; Hybridisation; H- bonding Molecular orbital theory for simple molecules such as diatomic molecule etc.
Types of Material: Metals, Semiconductors, Composite materials, Ceramics, Alloys, Polymers.

Unit II- Overview to Thermodynamics**:** The first and second laws of thermodynamics. Thermodynamic functions, heat capacity, enthalpy, entropy. Phase equilibrium in one component system, real gases, the interactions between gases.Ehrenfest classification of phase transition,the physical liquid surface; surface tension,curved surfaces, capillary action.

Theory of Solution and related topics: Liquid mixtures: free energy as a function of composition,ideal solutions and excess functions.
Equilibrium Electrochemistry; electrochemical cells, Methods for calculation of thermodynamic equilibrium. Electrochemical processes.

Unit III- Diffusion-Fick's Law, mechanisms of diffusion; generation of point defects; self-diffusion; the influence of the pressure and pressure gradient; Kirkendall effect; fast diffusion; influence of isotropic state; experimental methods of investigation of diffusion.

Unit IV- Reaction Kinetics and Photochemstry: Zero, First & Second order reactions. Dependence of ***k*** on Temperature.An overview of collision and activated complex theory. Steady State approximation.
Laws of Photochemistry, Fluorescence, Phosphorescence, Chemiluminescence, Jablonski diagram and quenching, Photochemistry of nanomaterials.

References: (NST 103)

1. Physical Chemistry, 1st Edition –Ball.
2. Thermodynamics-Glasston.
3. Principals of Physical Chemistry-Marron-Pruton.
4. Advanced Physical Chemistry – Atkins Peter, Paula Julio
5. Inorganic chemistry-Cotton-Wilkinson.
6. Introduction to Theoretical Chemistry – Jack Simons.

w.e.f. August 2008 **DEAN : USBAS**

Course Code NST-105 **Title: Nanoparticles & Micro-organisms Bionanocomposites**

L/T/P: 3/0/0

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: (NST – 105)

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 and Technology (Nanostructure Science and 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

w.e.f. August 2008 **DEAN : USBAS**

Course Code: NST-107 **Title: Elements of Material Science and Properties of Nanomaterials**

L/T/P: 4/0/0

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.

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References: (NST - 107)

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 Edition - Harold P. Klug, Leroy E. Alexander
8. Transmission Electron Microscopy: A Textbook for Materials Science (4-Vol Set)- David B. Williams and 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.

w.e.f. August 2008 **DEAN : USBAS**

Course Code: NST-109 **Title: Nanotechnology & Society (NUES)**
L/T/P: 1/0/0

Introduction to Societal Implications of Nanoscience and Nanotechnology, Nanotechnology Goals: Knowledge and scientific understanding of nature, Industrial manufacturing, materials and products, Medicine and the human body, Sustainability: Agriculture, water, energy, materials and clean environment, Space exploration, National security, Moving into the market.

References: (NST - 109)

1. Concept Document "Nanoscience & Technology Initiative" of DST, GOI, New Delhi, 2002.
2. Winner, Langdon, "Societal Implications of Nanotechnology", Testimony to ---- on science of the US House of Representatives, 2003.
3. Ethics in Engineering, M.Martin & R. Schinzinger, 4th edition, McGraw-Hill[0-07-283115-4];
4. Nanotechnology Regulation and Policy Worldwide (Artech House), Jeffrey H. Matsuura 2006.

w.e.f. August 2008 **DEAN : USBAS**

Course Code: NST-111 **Title: Life Sciences**
L/T/P: 2/0/0

UNIT I

1. Exploring Life
2. The evolutionary history of biological diversity
3. Brief classification of living kingdom
4. Differences between prokaryotes and eukaryotes
5. Plants and animal diversity:-Five kingdoms-Monera, Protista, Fungi, Plantae, Animalia; Three domains-Bacteria, Archaea and Eukarya

Unit II

6. General Structure of Bacteria, Archaea and Eukarya-Bacteri, Viruses, Fungi and Actinomycetes. Mechanisms of exchange of materials with the environment, ecological roles

Unit III

7. Chemistry of life : The structure and function of biological molecules of life-Basic structure, composition and function of carbohydrates, proteins, lipids, nucleic acids and enzymes.

Unit IV

8. Integrated control Systems: Nervous system and Endocrine system

Unit V

9. Natural synthesis of some biological materials: Their composition and properties-Teeth, Bone, silk etc.

w.e.f. August 2008 **DEAN : USBAS**

Course Code: NST-151 **Title: Laboratory-I**
L/T/P: 0/0/12

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.

Course Code: NST-153 **Title: Self Study-I**
L/T/P: 0/3/0

Presentations by the students on topics assigned and supervised by the faculty.

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w.e.f. August 2008 **DEAN : USBAS**

Semester-II

Course Code: NST-102 **Title: Fabrication techniques and Characterisation of Nanomaterials**

L/T/P: 4/0/0

Unit – I Fabrication of Nanomaterials by 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 Electro deposition.

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

Unit – III Optical Microscope and their description, operational principle and application for analysis of nanomaterials, UV-VIS-IR 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.

References: (NST-102)

1. Fabrication of fine pitch gratings by holography, electron beam lithography and nano-imprint lithography (Proceedings Paper) Author(s): Darren Goodchild; Alexei Bogdanov; Simon Wingar; Bill Benyon; Nak Kim; Frank Shepherd
2. Microfabrication and Nanomanufacturing- Mark James Jackson
3. A Three Beam Approach to TEM Preparation Using In-situ Low Voltage Argon Ion Final Milling in a FIB-SEM Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005), 11: 830-831 Cambridge University Press.
4. Processing & properties of structural naonmaterials - Leon L. Shaw (editor)

Course Code: NST-104 **Title: Soft Synthetic Routes & Some Novel Nanomaterials**

L/T/P: 4/0/0

Unit–I Chemical Routes for Synthesis of Nanomaterials: Chemical precipitation and co-precipitation; Metal nanocrystals by reduction, Sol-gel synthesis; Microemulsions or reverse micelles, myle formation; Solvothermal synthesis; Thermolysis routes, Microwave heating synthesis; Sonochemical synthesis; Electrochemical synthesis; , Photochemical synthesis, Synthesis in supercritical fluids

Unit–II Nanocomposites: An Introduction: Types of Nanocomposite (i.e. metal oxide, ceramic, glass and polymer based); Core-Shell structured nanocomposites Superhard Nanocomposite: Synthesis, applications and milestones.

Unit–III Nanopolymers: Preparation and characterization of diblock Copolymer based nanocomposites, Nanoparticles polymer ensembles; Assembly of polymer-Nanoparticles composite material; Fabrication of polymer-mediated organized Nanoparticles assemblies; Applications of Nanopolymers in Catalysis

Unit–IV Metal Nanoparticles: Size control of metal Nanoparticles and their characterization; Study of their properties: Optical, electronic, magnetic; Surface plasmon band and its application; Role in catalysis, Alloy Nanoparticles, Stabilization in Sol, Glass, and other media, Change of bandgap, Blueshift, Colour change in sol, glass, and composites, Plasmon Resonance.

References: (NST - 104)

1. Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge UK 2005.
2. Nanocomposite science and technology – P.M. Ajayan, L.S. Schadler, P.V. Braun, Wiley, New York.
3. Active Metals: Preparation, characterization, applications – A. Furstner, Ed., VCH, New York 1996.
4. Characterization of nanophase materials – Z.L Wang (ed), Wiley-VCH, New York 2000.
5. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
6. Nanostructured Silicon – based powders and composites – Andre P Legrand, Christiane Senemaud, Taylor and Francis, London New York 2003.
7. Polymer – clay Nanocomposite – T.J. Pinnayain, G.W. Beall, Wiley, New York 2001.
8. Block Co-polymers in Nanoscience – Massimo Lazzari, Guojun Liu, Sebastien Lecommandoux, Wiley, New York 2007.
9. Chemistry of nanomaterials : Synthesis, properties and applications by CNR Rao et.al.

w.e.f. August 2008 **DEAN : USBAS**

Course Code : NST-106 **Title : Nanodevices & Nanosensors**
L/T/P: 4/0/0

Unit-I Quantum and classical regimes of electron transport, mesoscopic transport. Diffusive transport: Boltzman transport equation, electron mobility and diffusion coefficient, Drift-diffusion model. Quantum electron transport; Double barrier Resonant-Tunneling structures: Coherent tunneling and sequential tunneling, Negative differential resistance, single electron tunneling, Coulomb blockade.

Unit-II Introduction to MEMs / NEMs, Electronic Transport in Nanostructures, Semiconductor devices to Single electron Transistors

Unit-III Nanosensors: Temperature Sensors, Smoke Sensors, Sensors for aerospace and defense: Accelerometer, Pressure Sensor, Night Vision System, Nano tweezers, nano-cutting tools, Integration of sensor with actuators and electronic circuitry Biosensors.

Unit-IV State of Art Ion-beam exchange in Nanostructure material. Nanostructure based Photovoltaic Cells.

References: (NST 106)

1. Sensors: Micro & Nanosensors, Sensor Market trends (Part 1&2) by H. Meixner.
2. Between Technology & Science : Exploring an emerging field knowledge flows & networking on the nanoscale by Martin S. Meyer.
3. Nanoscience & Technology: Novel structure and phenomea by Ping Sheng (Editor)
4. Nano Engineering in Science & Technology : An introduction to the world of nano design by Michael Rieth.
5. Enabling Technology for MEMS and nano devices -Balles, Brand, Fedder, Hierold.
6. Optimal Synthesis Methods for MEMS- G. K. Ananthasuresh
7. MEMS & MOEMS Technology and Applications- P. Rai Choudhury
8. Processing Technologies- Gandhi
9. From Atom to Transistor- Supriyo Datta

w.e.f. August 2008 **DEAN : USBAS**

Course Code: NST-108 **T itle: Scientific Computation & Simulation**
[NUES] **L/T/P: 1/0/0**

Unit-I Computational physics in Science & Technology, brief introduction to the Linux operating system; A review of the numerical techniques (Interpolations, differentiation, integration; Nonlinear equations, the bisection methods, Newton's method, root finding; Differential equations, Euler's method, the Runge-Kutta method; Matrices-inverting, finding eigenvalues and eigenfunctions, etc.).

Unit-II Simple problems based on section –I Using Matlab, Mathematica (mechanics, optics and quantum mechanics)/Atomistix and related softwares, Introduction to Labveiw software

Unit-III Introduction to Monte Carlo techniques, Random processes in science, Monte Carlo integration.

Unit-IV Applications and examples based on the Monte Carlo technique: Random walk, Percolation, Ising model, etc.

References: (NST 108)

1. 'Handbook of Theoretical and Computational Nanotechnology, Eds. Michael Rieth and Wolfram Schommers, 2006.
2. Introductory Computational Physics Kelvin and Godunov (Cambridge).
3. Computational Physics, R.C. Verma, K.C. Sharma & P.K. Ahluwalia.

w.e.f. August 2008 **DEAN : USBAS**

Course Code: NST-110 **Title: Solutions and Surface Phenomenon**

L/T/P: 4/0/0

Unit – I Adsorbtions on Solid Surfaces Freudlich and Langmuir Adsorption Isotherm. Gibbs Isotherm. Homogeneous and Heterogeneous Catalysis and its fundamental understanding at nanoscale. Role of nanometal and semiconductor particles in industry.

Unit – II Surface Chemistry: Colloidal state: Interfacial Porperties, Origin of Charge on Colloidal Particles, Determination of size of colloidal particles; Types of surfactants: Anionic, cationic, emini, zwitterionic & non-ionic (non-iogenic); Theory of surfactants; CMC – Effect of chemical structure, temperature; Kraft temperature; Emulsions & gels

Unit – III Phase Behaviour of Concentrated Surfactant Systems: Micelle type, Micellar growth, Micellar solution saturation; Structure of liquid; crystalline phases; Phase rule, Phase diagram, Binary and ternary phase diagrams of two components & three components, Surfactant geometry & packing; Introduction to microemulsion

Unit–IV Phase Transformations: Mechanisms of phase transformation; homogeneous and heterogeneous nucleation; spinodal decomposition; grain growth; precipitation in solid solution; transformation with constant composition; order-disorder transformations; Martensitic transformation

References: (NST 110)

1. Surfactants and Polymers in Aqueous Solution – K. Holmberg, B. Jonsson, B. Kronberg, B. Lindman, Wiley – England 2004.
2. Dynamics of Surfactant Self – Assemblies – Raoul Zana (Ed.), Taylor & Francis.
3. "Colloidal Dispersion" – Russel W. B, Saville D. A & Schowalter W. R, Cambridge University Press, 1989.
4. Fundamentals of Interface and Colloid Science – Lyklema J, Academic Press, Vol- 2
5. Introduction to Surface Physics – Martin Prutton, Oxford University Press (1994)
6. Introduction to Thermodynamics of Materials, - Gaskell, David R, 4th edition (1995), Taylor and Francis Publishing.

w.e.f. August 2008 **DEAN : USBAS**

Course Code: NST-112 [NUES]

Title: Business Enterprise in Nanotechnology & Projectmanagement

L/T/P: 1/0/0

COURSE DESCRIPTION/OBJECTIVES:

This course aims at imparting knowledge in respect of organizational and managerial structure of Indian businesses. Besides acquiring skills related to decision making, the students will be introduced to the tools and techniques, like PERT/CPM etc., for effective project management. The students will gain knowledge and experience through lectures, case studies and special topic presentations.

Lecture Schedule:

Lecture 1. : Indian Business Enterprise

Lecture 2 : Business Organization design and structure

Lecture 3. : Introduction to Organization Behavior

Lecture 4: Team building and Motivation

Lecture 5: Leadership, Communication and interpersonal skills

Lecture 6 : Managing R&D and Innovations

Lecture 7: Entrepreneurship

Lecture 8 : Analyzing business environment

Lecture 9: Decision Making techniques

Lecture 10: Project Management

Lecture 11: PERT / CPM – I

Lecture 12 : PERT / CPM – II

Lecture 13 : Presentations

References: (NST: 112)

1. Concept Document "Nanoscience & Technology Initiative" of DST, GOI, New Delhi.

w.e.f. January 2009

DEAN : USBAS

Course Code: NST-152 **Title: Laboratory-II**
L/T/P: 0/0/12

Section A

1. To investigate adsorption of oxalic acid from aqueous solution by activated charcoal and examine the validity of Freundlich and Langmuir adsorption isotherm.

2. Determination of critical micelle concentration of ionic and non-ionic surfactant by surface tension method.

3. Determination of mutual solubility curve of phenol & water, and hence the consulate point. Study the effect of presence of salt to the above system.

4. Preparation of water-in-oil microemulstion and measurement of droplet sizes by Dynamic Light Scattering (DLS).

5. To study the effect of salt & valency of adsorbing ions on particle dispersion stability.

6. Preparation of quantum dot (ZnS) nanoparticles and estimation of band gap from band edge.

7. Preparation of liquid crystals

Section B

1. Synthesize copper oxide nanoparticles by sol-gel method and determine the average size of nanoparticles using Zetasizer.

2. Synthesize nickel oxide nanoparticles by sol-gel method and determine the average size of nanoparticles.

3. Fabricate silver nanoparticles embedded in silica glass by ion exchange method and study surface plasmon resonance using UV-visible spectroscopy.

4. Fabricate copper nanoparticles embedded in silica glass by ion exchange method and determine the size of nanoparticles using optical absorption spectroscopy.

5. Synthesize silver nanocrystals in solution by citrate reduction method and study the effect of capping using optical absorption spectroscopy.

6. Study the growth kinetics of silver nanoparticles embedded in ion exchanged glass at different temperatures using optical absorption spectroscopy.

Course Code: (NST-154) **Title: Self Study-II**
L/T/P: 0/3/0

Presentations by the students on topics assigned and supervised by the faculty.

Course Code: (NST-156) **Title : Scientific Computation & Simulation**
L/T/P: 0/0/4

The syllabus will remain same as for the paper NST-108.The students will be made to practice and learn computational work in this lab.

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w.e.f. August 2008 **DEAN : USBAS**

Approved in 27th meeting of the academic council held on 15-06-2009. Agenda Item No. 27.9

Semester- III

Course Code: NST-201 **Title: Advanced Nanomaterials**
L/T/P: 3/0/0

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

Unit-II Nanostructure Magnetism; Effect Bulk Nanostructuring of Magnetic property; Gaint and colossal Magnetic resistance; Super Para Magnetism in metallic nanoparticle; Super para magnetism / FM in Semi-conduction quantum dots.

Unit-III Carbon Nano Structures: Introduction; Fullerenes, 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 Properties. One dimensional TEM; Composite TEM; Applications.

References: (201)

1. Novel Nanocrystalline 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 : Fundamentals Of Theory, Optics And Transport Devices - S. Subramony & S.V. Rotkins.
8. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell.
9. CARBON NANOTECHNOLOGY- Liming Dai.
10. Nanotubes and Nanowires- CNR Rao and A Govindaraj RCS Publishing.
11. CRC Handbook of Thermoelectrics, Ed. CR Rowe

Course Code: NST-203 **Title: Semiconductors Nanostructure & Nano-particle**
L/T/P: 3/0/0

Unit –I Semiconductor nanoparticles Synthesis, Cluster compounds, quantum-dots from MBE and CVD, wet chemical methods, reverse micelles, electro-deposition, pyrolytic synthesis, self-assembly strategies.

Unit –II Semiconductor nanoparticles: size–dependant 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: (NST – 203)

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.

w.e.f. August 2008 **DEAN : USBAS**

Electives

Course Code: NST 205 **Title: Molecular Nanoelectronics**

L/T/P: 3/0/0

Unit –I Introduction: Recent past, the present and its challenges, Future, Overview of basic Nanoelectronics.

Unit –II Molecular Electronics Components: Characterization of switches and complex molecular devices, polyphenylene based Molecular rectifying diode switches. Technologies, Single Electron Devices, Quantum Mechanical Tunnel Devices, Quantum Dots & Quantum wires.

Unit –III Nanoelectronic & Nanocomputer architectures and nanotechnology: Introduction to nanoelectronic and nanocomputers, Quantum DOT cellular Automata (QCA), Single electron circuits, molecular circuits Nanocomputer Architecture.

Unit –IV Spintronics: Introduction, Overview, History & Background, Generation of Spin Polarization Theories of spin Injection, spin relaxation and spin dephasing, Spintronic devices and applications, spin filters, spin diodes, spin transistors.

References: (NST 205)

1. Nanoelectronics & Nanosystems: From Transistor to Molecular & Quantum Devices: Karl Goser, Jan Dienstuhl and others.
2. Concepts in Spintronics – Sadamichi Maekawa
3. Spin Electronics – David Awschalom
4. From Atom to Transistor-Supriyo Datta

Course Code: NST 207 **Title: Photonics and Plasmonics**
L/T/P: 3/0/0

Physics of Linear Photonic Crystals: Maxwell's Equations, Bloch's Theorem, Photonic Band Gap and Localized Defect States, Transmission Spectra, Nonlinear Optics in Linear Photonic Crystals, Guided Modes in Photonic Crystals Slab

Technology, Materials, and Fabrication of Photonic Crystals: Choices of Materials: Semiconductors, Amorphous, and Polymers, Fabrications of Photonic Crystals Structures (1-D, 2-D, 3-D)

Applications of Photonic Crystals Devices: 1-D Photonic Crystals, Couplers, Waveguides, High-Q Cavities, etc, 2-D Photonic Crystals , Photonic Crystal Fibers, 4 Tunable Photonic Crystal Filters

Physics of Nonlinear Photonic Crystals: 1-D Quasi Phase Matching, Nonlinear Photonic Crystal Analysis, Applications of Nonlinear Photonic Crystals Devices, Materials: LiNbO3, Chalcogenide Glasses, etc, Wavelength Converters, etc

Elements of Plasmonics: Introduction to Plasmonics, merging photonics and electronics at nanoscale dimensions, single photon transistor using surface plasmon, nanowire surface plasmons-interaction with matter, single emitter as saturable mirror, photon correlation, and integrated systems. All optical modulation by plasmonic excitation of quantum dots, Channel plasmon-polariton guiding by subwavelength metal grooves, Near-field photonics: surface plasmon polaritons and localized surface plasmons, Slow guided surface plasmons at telecom frequencies.

References: (NST 207)

1. The Handbook of Photonics By Mool Chand Gupta, John Ballato
2. Nanotechnology for Microelectronics and Optoelectronics - J. M. Martinez-Duart, Raúl J. Martín-Palma, Fernando Agullo-Rueda
3. Nanoplasmonics, From fundamentals to Applications vol 1 & 2- S. Kawata & H. Masuhara
4. Optical Properties of Photonic Crystals-K. Sakoda
5. Applied Photonics by Chai Yeh
6. Silicon Photonics: An Introduction by Graham T. Reed, Andrew P. Knights

w.e.f. August 2008 **DEAN : USBAS**

Course Code: NST 209 **Title: Carbon Nanotube & Its Functionalisation**

L/T/P: 3/0/0

Preparation of Carbon Nano-Tubes: CVD and other methods of preparation of CNT

Properties of Carbon Nanotubes: Electrical, Optical, Mechanical, Vibrational properties etc.

Applications of Carbon Nanotubes: Field emission, Fuel Cells, Display devices

Functionalization of Carbon Nanotubes: Carbon Nanotubes, Functionalization of Carbon Nanotubes, Reactivity of Carbon Nanotubes,

Covalent Functionalization: Oxidative Purification, Defect Functionalization –Transformation and Modification of Carboxylic Functionalization like Amidation, Thiolation, Halogenations, Hydrogenation, Addition of Radicals, Addition of Nucleophilic Carbenes, Sidewall Functionlaization through Electrophilic Addition, Cycloadditions, Carbenes Addition, Addition of Nitrenes, Noncovalent Exohedral Functionalization, Endohedral Functionalization

Other Important Carbon based materials: Preparation and Characterization Fullerene and other associated carbon clusters/molecules, Graphene-preparation, characterization and properties, DLC and nanodiamonds.

References: (NST 209)

1. Nanoscale materials -Liz Marzan and Kamat
2. Physical properties of Carbon Nanotube-R Satio
3. Applied Physics Of Carbon Nanotubes : Fundamentals Of Theory, Optics And Transport Devices - S. Subramony & S.V. Rotkins
4. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell
5. CARBON NANOTECHNOLOGY- Liming Dai
6. Nanotubes and Nanowires- CNR Rao and A Govindaraj RCS Publishing

w.e.f. August 2008 **DEAN : USBAS**

Course Code: NST 211 **Title: Nanocomposites**

L/T/P: 3/0/0

Metal based nanocomposites: Metal-Oxide or Metal-Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality. Metal-metal nanocomposites, some simple preparation techniques and their new electrical and magnetic properties.

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

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

Polymer based nanocomposites: Preparation and characterization of diblock Copolymer based nanocomposites; Polymer-carbon nanotubes based composites, their mechanical properties, and industrial possibilities.

References: (NST 211)

1. Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V. Braun
2. Physical Properties 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 Vepr¡ek (Review Article) JVST A, 1999
5. Electromagnetic and magnetic properties of multi component metal oxides, hetero
6. Nanometer versus micrometer-sized 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

w.e.f. August 2008 **DEAN : USBAS**

Course Code: NST 211 **Title: Computational Nanoscience**
L/T/P: 3/0/0

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

Unit – II Monte Carlo Simulations; Computational methods and Simulations from ab initio to multiscale 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.

References: (NST: 211)

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

w.e.f. August 2008 **DEAN : USBAS**

Course Code: NST 213 **Title: IPR & Nanotechnology**
L/T/P: 1/0/0

Nanotechnology with its vast potential applications in day to day life will surely face lot of legal challenges. The objective of this course will be focused towards sensitizing the students towards relating IPR with relation to Nano Science.

Course Code: (NST-251) **Title: Self Study-III**
L/T/P: 0/2/0

In this course the students are asked to make comprehensive presentations relevant to the course content under the direct supervision of the faculty members.

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