PONDICHERRY UNIVERSITY
PONDICHERRY – 605 014 INDIA

M.Tech. Program in Nano Science & Technology (NST)

Department of Physics will mentor the M.Tech. program in Nano Science & Technology (NST), which is to be introduced from the academic year 2010-2011.

M.Tech. Nanoscience & Technology is highly interdisciplinary course to train the students from many science and engineering disciplines, such as, Physics, Chemistry, Materials Science, Electronic, Electrical, Computer, Mechanical, Metallurgy & Materials, Chemical, etc., and develop them as highly skilled Nanoscientists as well as Nanotechnologists to lead high level research group in universities, industry and also industrial scientific instrument sectors. Selected students will get rigorous training in the following areas.

1. Theory and experiments (laboratory) on Nanomaterials and various techniques used for the fabrication and characterization of nanostructures.

2. Modeling, Design and Simulations of nanostructured materials.

3. Design, Fabrication and Testing of Devices in Nanoelectronics, Nanophotonics and Nanobioelectronics.

4. Imparting the state of art of Nanotechnology to the Society

5. Develop skills of Business Enterprises in Nanotechnology and Project Management. In addition, develop skills in protecting Intellectual Property rights for the inventions of Nanotechnology

The M.Tech. course will be taught by eminent faculty from various disciplines like, Physics, Chemistry, Biology, Biotechnology, Biomedical, Electrical, Mechanical and Metallurgy & Materials Science Engineering. Pondicherry University has excellent research facilities, available in Physics, Chemistry, Biology, Biotechnology, Earth Science and Central Instrumentation Facility. Efforts are under process to procure laboratory facilities specifically related to the M.Tech. Nanoscience & Technology program.

Details of the program

- Duration : 2 Years (4 semesters)
- Total Credits : 100
- Admission Criterion : University Entrance Exam / GATE Score
- Number of Seats : 17
- Eligibility : M. Sc. (Physics / Applied Physics / Electronics / Materials Science/Chemistry);
  BE / B.Tech (Electronics / Electrical / Instrumentation/ Mechanical / Metallurgy & Material Engg. / Biotechnology /Chemical Engg. or Technology)
  Minimum 55% aggregate marks in qualifying examination.
  Those who apply with M.Sc. background should have mathematics in undergraduate level.

Teaching and Learning Methods
Lectures, tutorials and seminars form the main methods of course delivery enhanced by individual and group project work, laboratory work, computing workshops and industrial visits.

Assessment Methods
Assessment will be through Chaise Based Credit System (CBCS) through session (laboratory reports, class tests, set assignments) or by continuous assessment (designing, computer practical, seminar papers, project reports etc.) and end semester examinations.

Employment:
It is envisaged that the M.Tech. graduates in Nanoscience and Nanotechnology will gain employment in research groups working in universities / institutions / industry and also industrial scientific instrument sectors.

Prof.N.SATYANARAYANA
Head, Center for Nano Science and Technology
Department of Physics, Pondicherry University

Scheme of Courses and Credits for M.Tech Nano Science & Technology

1. Semester - I ---------- Credits: 25
2. Semester - II ---------- Credits: 25
3. Semester - III ---------- Credits: 30
4. Semester - IV ---------- Credits: 20

Total Credits: 100

Ist YEAR

Semester - I **Credits: 25**

S. No.	Course Code	Title of the course	Credits	Remarks L/T/P
1.	NST-111	Review of Quantum Mechanics and Electromagnetic theory	4	4/0/0
2.	NST-112	Quantum Mechanics of confined system and Quantum Chemistry	4	4/0/0
3.	NST-113	Nanothermodynamics and Kinetics	4	4/0/0
4.	NST-114	Chemical & Physical synthesis Processes and Characterization Techniques of nano materials	4	4/0/0
5.	NST-115	Nanostructures Fabrication and Characterization	4	4/0/0
6.	NST-110	Laboratory	4	0/0/8
7.	NST-116	Preparing and giving talks, preparing posters, scientific writing, teaching and management skills	1	1/0/0
		Total Credits	**25**	

Semester - II **Credits: 25**

S. No.	Course Code	Title of the course	Credits	Remarks L/T/P
1.	NST-121	Physical Properties of Nanomaterials	4	4/0/0
2.	NST-122	Self Assembly of Nanostructures	4	4/0/0
3.	NST-123	Nanostructures: Modeling, Design & Simulations	4	4/0/0
4.	NST-124	Nanocatalysis and Colloidal Systems	4	4/0/0
5.	NST-125	Biology for Nanosciences	4	4/0/0
6.	NST-120	Laboratory	4	0/0/8
7.	NST-126	NanoTechnology: Society and Environment	1	1/0/0
		Total Credits	**25**	

NST-237	**Summer training (Report & Seminar)**	

IInd YEAR

Semester - III **Credits: 30**

S. No.	Course Code	Title of the course	Credits	Remarks L/T/P
1.	NST-231	Polymers and Nanocomposites	4	4/0/0
2.	NST-232	MEMS and NEMS	4	4/0/0
3.	NST-233	Elective – a	4	4/0/0
4.	NST-234	Elective – b	4	4/0/0
5.	NST-235	Elective – c	4	4/0/0
6.	NST-230	Laboratory	4	0/0/8
7.	NST-236	NanoTechnology: Business Enterprise, Project management & Intellectual Property Rights.	1	1/0/0
8.	NST-237	Summer training (Report & Seminar)	5	
		Total Credits	**30**	

Semester - IV **Credits: 20**

S. No.	Course Code	Title of the course	Credits	Remarks
1.	NST-241	Project	20	
		Total Credits	**20**	

ELECTIVES:

1. Nano Structures and Devices
1a. NanoElectronics
1b. Nanophotonics
1c. Nanomagnetics

2. Materials simulation
2a. Density functional theory and Abinitio calculations & simulations
2b. MD & MC simulations
2c. Continuum simulations & Multi scale modelling

3. Nanobioelectronics
3a. Genomics and Proteomics
3b. BioElectroMechanics
3c. Bioelectronics Devices

Minimum credit requirement = 100; All teaching, learning and evaluations will follow Choice Based Credit System (CBCS).

M.Tech. Program in Nano Science & Technology (NST)

Syllabi for courses

Ist YEAR

Semester - I **Credits: 25**

1. NST-111: Review of Quantum Mechanics and Electromagnetic Theory, 4-Credits, 4- hours per week

Review of Quantum Mechanics:
Quantum mechanics of free particle confined to one, two and three dimensional box. Quantum mechanics of free particle confined to a ring, surface of a sphere. Quantum mechanics of a free particle confined to a spherical trap. Electron in a periodic potential, Block theorem, Electron energy bands in solids: Conductors, Insulators and Semiconductors, Density of states for solids.

Time Independent Perturbation Theory, Time Dependent Perturbation Theory, Density Matrix Formulation: Concept of Coherences, Scattering Theory, Identical Particles

Quantum mechanics of Atoms and Molecules: Hamiltonian and Wave functions – Orbital approximation for multielectron atoms - Pauli's Anti-symmetry principle – Born – Oppenheimer approximation – MO Theory - LCAO approximation – Orthogonality of MOs - MOs of H_{2+} and H_{2-} Excited states of H_2-VB theory – Comparison of VB vs MO methods – Non-crossing rule, correlation of homo-nuclear diatomics, MO configuration, Electronic states and Term symbols.

Review of Electromagnetic Theory:
Electrodynamics: Maxwell Equations in Vacuum and Matter, Continuity Equation, Poynting Theorem, Electromagnetic Waves in One and 3 Dimension, Electromagnetic waves in Vacuum and Matter, Reflection and Transmission at Normal and Oblique Incidences, Complex Refractive Index and Dispersion relation, Guided Waves in Wave Guides, Rectangular wave guides and Coaxial Transmission line, Scalar and Vector Potentials Gauge Transformation Pont Charges, Dipole Radiation -Electric and Magnetic Dipole Radiation and Arbitrary Source, Radiation Reaction and Physical Basis for radiation Reaction

Books:

1. Quantum mechanics, Ghatak & Loganathan, McMillan
2. Quantum mechanics, L. I. Schiff
3. Quantum Mechanics, Vol I and Vol II, Claude Cohen-Tannaoudji, Bernard Diu, Franck Laloe, John Wiley & Sons (2005)
4. Introduction to quantum mechanics, Dicks and Witke
5. Quantum mechanics, J. L. Powell and B. Craseman, Addison-Wesley
6. Quantum mechanics, Gordon Baym Craseman
7. Introduction to Electrodynamics D.J. Griffiths Printice-Hall, India
8. Classical electromagnetism J. D. Jackson John Wiley Publications
9. Principles of electricity magnetism Panofsky and Philip,, Addison Wisley
10. Electromagnetic fields and waves, Paul Lorrain and Dale Corsor, W. H. Freeman & Co

2. NST-112: Quantum Mechanics of confined system and Quantum Chemistry, 4-Credits, 4- hours per week

Quantum Confinement and Quantum structures: Quantum wells, Quantum wires and Quantum dots. Quantum confinement of small systems: Conductors - metal to insulator transition, Semiconductors - confining excitons. Band gap of nanomaterials - band gap tuning. Tunneling of electrons across the electrical barriers, Scanning tunneling microscope, tunneling of electrons from a quantum dot. Restricting the quantum tunneling from quantum dot using Coulomb blockade and overcoming uncertainty methods. Single electron transistor.

Symmetry & Group theory: Axioms and Theories of group – Sub - groups – Classes. Molecular symmetry and point groups: Symmetry elements and operators, classes of symmetry operation, Symmetry classification of molecules. Matrix representation of symmetry operations, representation of groups, character, reducible and irreducible representations. Great orthogonality theorem, character tables, symmetry properties of Hamiltonian operator, Wave functions as basis for irreducible representations.

Theories of Bonding: VB theory and Lewis electron pair bonding – VESPR theory – Concept of oxidation numbers- the simple Huckel method – Assumptions – Determinant, Energies and Wave functions – Extended Huckel Method – Overlap – Population analysis – FMO theory – Interaction and Walsh diagrams – s-p mixing – Non –crossing rule – Conjugation and Hyperconjugation – FMOs of functional groups – Isolobal analogy – Tight binding approximation – Band structure and Density of state calculations- Population Analysis.

Bonding in Nanostructures: Graphite – Fullerenes – Carbon nanotubes – bonding in armchair, zigzag, chiral tubes – n-m=3q rule – inorganic nanotubes – Sheets vs tubes – nature of Frontier bonds – Band gap Engineering – Deltahedral nanotubes – Saturated Nanowires – Reactivity of nanotube surfaces – Funtionalization of nanotubes.

Books:

1. C. Delerue, M. Lannoa, Nanostructurs: Theory and Modeling, Springer, 2004
2. M.A. Stoscio, M. Dutta, Phonons in Nanostructures, Cambridge University Press, Cambridge, New York 2001
3. B.E. Serndius, Surface Modes in Physics, 1st Edition, Wiley-VCH, New York 2001.
4. J.C. Woo, and T. Yao, Physics and Applications of Semiconductor Quantum Structures, IOP Publishing, 1999.
5. Y. Masumoto and T. Takagahara, Semiconductor Quantum Dots: Physics, Spectroscopy and Applications, Springer 2002.
6. J.P.Lowe and K.A.Peterson,Quantum Chemistry-ElsevierAcademic Press,New York,2006.
7. P.W.Atkins and R.S.Friedman:Molecular Quantum Mechanics,Oxford,2005
8. T.A.Albright, J.KBurdett,M.H.Whangbo,Orbital Interactions in Chemistry,John-Wiley&Sons, 1985
9. F. Jensen, Introduction to computational chemistry, Wiley, NY, 2007.
10. R. Hoffmann, Solids and surfaces, Wiley – VCH, NY, 1988.

3. NST-113: Nanothermodynamics and Kinetics, 4-Credits,
4- hours per week

Thermodynamic laws, Entropy, Statistical thermodynamics: micro-and macro-states. Unitary and multi-component systems, Gibbs phase rule, phase diagrams relevant to macro systems and for nanoscale materials formation, Phase transitions

General criterion for equilibrium-chemical potential and Gibbs free energy. Physical phenomena unique to small systems- classical thermodynamics- non-equilibrium statistical mechanics- distinction between standard thermodynamics and the thermodynamics of small systems-thermodynamically instability.

Statistical Thermodynamics: Concepts of probability and Maxwell Boltzmann distribution. Different ensembles and partition functions. Thermodynamic functions using appropriate partition functions. Fermi-Dirac and Bose-Einstein statistics and statistical basis of entropy. Heat capacity of solids. Debye and Einstein models. Thermodynamic functions of ideal gases, translational, vibrational and rotational contributions at different levels of approximation. Application of statistical thermodynamics concepts to ortho para hydrogen internal rotation - calculation of equilibrium constants.

Phase Transformations: Fick's laws of diffusion, solution of Fick's second law and its applications, atomic model of diffusion and role of crystal defects, temperature dependence of diffusion coefficient, Kirkendall effect. Thermodynamic considerations: Free energy of alloy phases and free energy-composition curves for binary systems. Nucleation and growth - energy considerations; heterogeneous nucleation, growth kinetics, overall transformation rates. Solidification: Nucleation and growth from liquid phase, stable interface freezing,cellular and dendrite growth,freezing of ingots, nucleation and grain size , segregation, directional solidification, growth of single crystals. Precipitation from solid solution: Homogeneous and heterogeneous nucleation of precipitates, the aging curve, mechanisms of age hardening, examples from Al-Cu and other alloy systems. Order-disorder Transformation: Examples of ordered structures, long and short-range order, detection of super lattices, influence of ordering on properties.

Books:

1. G. M. Barrow, Physical Chemistry (V Edition), McGraw Hill international Series, 1988.
2. S. Glasstone, Thermodynamics for chemists, Affiliated East West Press, 1965.
3. P. W. Atkins, Physical Chemistry, Sixth edition, Oxford University Press, 1990.
4. B. C. McClelland, Statistical Thermodynamics, Chapman and Hall, 1973.
5. L. K. Nash, Elements of classical and statistical thermodynamics, Addison-Wesley, 1970.
6. M. C. Gupta, Statistical Thermodynamics, Wiley Eastern Limited, 1993.
7. J. Rajaram and J. C. Kuriacose, Thermodynamics for Students of Chemistry, Shobanlal Nagin Chand Co, 1986.
8. N. D. Smith, Elementary Statistical Thermodynamics, Plenum Press, 1982.
9. V. Raghavan, Solid State Phase Transformations, Prentice-Hall of India Pvt. Ltd. New Delhi, 1987.
10. D.A. Porter and K.E. Easterling, Transformations in metals and alloys, 2nd Edition, CRC Press, 1992.

4. NST-114: Chemical & Physical synthesis processes and characterization techniques of nano materials, 4-Credits, 4- hours per week

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, Core-Shell structured nanocomposites Electrochemical synthesis; , Photochemical synthesis, Synthesis in supercritical fluids. Metal Nanoparticles: Size control of metal Nanoparticles and their characterization; 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.

Techniques for Materials Characterization and Transport properties: XRD, FTIR, UV-Visible, NMR, ESR, Mossebauer spectroscopy, X-ray absorption techniques, Photoacousitc spectroscopy Differential Scanning Calorimeter (DSC), Differential Thermal Analyzer (DTA), Thermo gravimetric Analysis(TGA) or TG/DTA (DSC), EPMA, SIMS, XPS (ESCA), UV- Photoemission and inverse photoemission, Auger electron spectroscopy, Positron annihilation spectroscopy, Neutron diffraction, SEM, TEM, EDX, WDX, AFM, STM and SNOM, Optical mapping, auto radiography, Electron Micrography Surface area determination by BET- method, Particle size by light scattering method, Zeta potential, Gas Liquid Chromatography, High Performance Liquid Chromatography, Resistivity, Conductivity through impedance, Hall Mobility, Thermoelectric Power, Transport number and band gap measurements.

Vacuum technology: Physical principles of various types of vacuum pumps: Rotory oil, diffusion, Molecular drag, Turbomolecular, Getter and getter-ion, Sorption, Cryopump. Pressure measuring meters: Pirani, Ionization, penning, magnetron ionization, magnetic deflection gauges. Vacuum system design, Construction, Leak detection, Vacuum system in practice. Low temperature techniques liquid nitrogen and liquid helium.

Books:

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.

10. Processing & properties of structural naonmaterials - Leon L. Shaw (editor)
11. Elements of X-ray Diffraction by Cullity, B. D.,, 4th Edition, Addison Wiley, 1978.
12. The Structure and Properties of Materials by Rose, R.M., Shepard L.A., and. Wulff, J., Wiley Eastern Ltd.
13. Electron Beam Analysis of Materials by Loretto, M. H., Chapman and Hall, 1984.
14. Vacuum Physics and Techniques by T.A. Delcher, Chapman & Hall.

5. NST-115: Nanostructure Fabrication and Characterization
4-Credits, 4- hours per week

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. Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM),. Optical and electron Microscope techniques, X-ray diffraction, UV-VIS- and IR Spectrophotometers.

Electron microscopy: The Illumination system, Specimen Preparation, Indexing Diffraction Patterns, Convergent Beam Techniques, Imaging in the TEM, EDX and WDX

Books:

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 FIBSEM Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005), 11: 830- 831 Cambridge University Press.
4. Transmission Electron Microscopy and Diffractometry of Materials, B.Fultz, and J.M.Howe, Second Edition, 2002, Springer, Germany.
5. Electron Diffraction in the Transmission Electron Microscope, P.E. Champness, 2001, Garland Science, USA.
5. Transmission Electron Microscopy, D.B. Williams and C.B. Carter, 1996, Springer, USA.
6. Practical Electron Microscopy in Materials Science, J.W. Edington, 1976, 4 volumes reprinted by Tech Books, Herndon, USA.
7.Electron Microscopy and Structure of Materials, Editor: Gareth Thomas, 1972, University of California Press, Berkeley.
8.Transmission Electron Microscopy of Metals, Gareth Thomas, 1962, John Wiley & Sons, New York.
9.Transmission Electron Microscopy of Materials, Gareth Thomas and M.J. Goringe, 1979, John Wiley & Sons, New York.

6. NST-110: Laboratory, 4-Credits, 8 - hours per week

I. Preparation and testing of silver nanoparticles by chemical route.
II. Synthesis of ZnS nanoparticles by chemical route and determination of band structure through UV-Vis spectroscopy.
III. Synthesis and testing of Cadmium Selenide Quantum dots.

IV. Synthesis and characterization of SiO_2 Spheres.
V Synthesis and characterization of multi component Ferrites

Five more experiments from simulations

7. NST-116 Preparing and giving talks, preparing posters, scientific writing, teaching and management skills, 1-Credit, 1 - hour per week

Semester - II **Credits: 25**

Syllabai for courses

1. NST-121: Physical Properties of NanoMaterials, 4-Credits, 4- hours per week

Lattices, Crystal Symmetries, X-ray diffraction Phonons, Band theory of solids Structure–property relationships, Symmetry of physical properties, Atomistic arguments, Density, transformations, Symmetry operations, Symmetry elements and stereographic projections, Point groups and their stereograms, Crystallographic nomenclature, Transformation operators for the crystallographic symmetry elements, Transformation operations for the thirty-two crystal classes, Physical properties, Pyroelectric and electrocaloric tensors, Dielectric tensor, Stress and strain tensor, Thermal expansion, Piezoelectricity tensor, Elasticity tensor, Magnetic phenomena, Electrical resistivity, Thermal conductivity Diffusion and ionic conductivity Galvanomagnetic and thermomagnetic, Thermoelectricity, Piezoresistance phenomena, Photoelasticity and acousto-optics, Electro-optic phenomena, Magneto-optics, Chemical anisotropy

Books:

1. Nanoparticles and Nanostructured films: Preparation, Characterization and Applications. Ed. J H Fendler, (Wiley –VCH, NY, 1998)
2. Fundamental properties of nanostructured materials, Ed. D. Fiorani (World Scientific, Singapore, 1994)
3. Adv. Catalysts and Nanostructured materials: modern synthesis methods. Ed. H.R. Moser (Academic, San Diego, 1996)
4. Semiconductor Quantum Dots, L. Banyai and S.W. Koch (World Scientific, Singapore, 1993)
5. Encyclopedia of nanoscience and nanotechnology, Vol.8 Ed. H.S. Nalwa (American Scientific Publishing, 2004)

2. NST-122: Self Assembly of Nanostructures, 4-Credits, 4- hours per week

Self organization of nanoparticles, Assembling and patterning of particles, Fabrication of organic/inorganic mesoporous materials, Langmuir Bladgett films, SAM, Microcontact Printing, Lithographics, Nanomanipulators and Grippers, Bottom-Up manufacturing, Molecular Scale Assembly Lines. Macroscopic expressions of Natural Nanomaterials, Molecular biology and Genetics.

Books:

1. Prospects in Nanotechnology: Toward Molecular Manufacturing, Markus Krummenacker and James Lewis (Editors), Wiley 1995.

3. NST-123: Nanostructures: Modeling, Design & Simulations,
4-Credits, 4-hours per week

Scientific Modeling: Analytical methods: Ordinary differential equations - Normal modes, Laplace transform and z-transform technique. Partial differential equations - separation of variables, transform techniques. Variational principles - Fermant's principle, Hamilton's principle, constraints and Lagrange multipliers. Modeling random systems - random variables, joint distribution, characteristic function, stochastic differential equation.

Numerical Methods: Numerical Algorithms - Computer program -Approximations in Mathematical model building - Numerical Differentiation -Numerical integration: Newton-Cotes integration formulae and Gauss quadrature method. Numerical solution of a system of ordinary differential equations: Runge Kutta method and adaptive step size control.

Numerical Linear Algebra: Matrices, Solution of linear algebraic equations and singular value decomposition, Eigenvalue problems, Computing Eigenvalues and Eigenvectors, Iterative methods for linear systems, Software for linear systems - LINPACK and LAPACK

Probability , Random numbers and Monte Carlo methods: Uniformly distributed Pseudo random numbers, Exponentially and Normally distributed Pseudo random numbers, Testing of pseudo random number sequences, Simulation of radioactive decay, Numerical Integration using Monte Carlo simulation techniques

Partial differential equations : Finite difference methods for Parabolic, Hyperbolic and Elliptic equations, Truncation errors, consistency, stability, Introduction to finite element methods and finite volume methods.

Books:

1. Computational physics- Problem solving with computers, Rubin H. Landau, Manuel J. Paez, John Wiley & sons 1997.
2. Numerical Recipes in Fortran / F-90 / C, W.H. Press et. al., Cambridge Univ. Press.
3. A First Course in Computational Physics, P.L. DeVries, John Wiley.
4. Numerical Methods for Engineering Application, J.H. Ferziger, John Wiley.
5. Scientific Computing: An Introduction with Parallel Computing, G. Golub and J.M. Ortega, Academic Press.
6. Scientific Computing: An Introductory Survey, Michael T. Heath, McGraw-Hill, New York, 2002.
7. Computational Physics, J. M. Thijssen, Cambridge University Press, Cambridge, 1999.
8. Guide to Neural Computing Applications, L. Tarassenko, Arnold Publishers, 1998.

Genetic Algorithms in Search, Optimization, and Machine Learning, D. E. Goldberg, Addison Wesley, Reading, Massachusetts, 1989.

4. NST-124: Nanocatalysis and Colloidal Systems, 4-Credits, 4- hours per week

Nanocatalysis: Role of transition methals and metal oxides in homogeneous and heterogeneous catalysis and their mechanism of catalysis, manufacturing of these catalysts in nano form and their characterization. Silica, alumina, carbon as high temperature carriers for catalysts. Use of nanocatalysts in automobile pollution control, photocatalysis of toxics in effluents, gas sensors. Reactor design for manufacture of nanocatalysts : Design of flame aerosol reactors, diffusion and premixed flame reactors, co-precipitation reactors. Catalytic vapour – liquid –solid growth mechanism for understanding particle formation and growth during chemical vapour deposition, particle dynamics and CFD simulations of flame process based on fundamental equations for flow, heat and mass transfor, aerosol dynamics in flames.

Nature of colloidal solutions, Surface tension, Wetting, Solubulization, Despersion, Detergency. Thermodynamics of absorption, Surfactants and Self assembly, Emulsions and Microemulsions, Charged colloids, colloidal stability.

Books:

1. Nanoparticles and Nanostructured films: Preparation, Characterization and Applications. Ed. J H Fendler, (Wiley –VCH, NY, 1998)
2. Fundamental properties of nanostructured materials, Ed. D. Fiorani (World Scientific, Singapore, 1994)
3. Adv. Catalysts and Nanostructured materials: modern synthesis methods. Ed. H.R. Moser (Academic, San Diego, 1996)

5. NST-125: Biology for Nanosciences, 4-Credits, 4- hours per week

Nature, Properties and Function of Carbohydrates:Sugars-dissacharides, trioses, tetroses, pentoses, hexoses - stereoisomers-aminosugars, phosphosugars, sugar derivatives, deoxysugars - Oligossacharides-polyssacharides-homo and hetero polyssacharides, amylose, amylopectin, dextrans, limit dextran – starch - glycogen-synthesis and degradation-glycolysis, TCA cycle, glycosyl moieties, cell wall polyssacharides - cellulose chitin – cellobiose –carbohydrate antigens - lectin binding antigens - natural glues/carbohydrate gums-xanthan, mannans - structural aspects of carbohydrates.

Nature, Properties and Function of Proteins: Amino acids, - essential and non essential - dipeptides, oligipeptides, polypeptides- monomers,dimers, oligomers - fibrous proteins and globulins - primary, secondary, tertiary, quarternary structures- disulfides, hydrogen bonds, schiff's base- amino and carboxy termini - alpha helix and beta pleats – triple helix - Ramachandran plots – protein synthesis, translation, post translational modifications –glycosylation, lipoylation - glycolproteins, proteoglycans, glycosaminoglycans – protein degradation – enzymatic and non enzymatic immunoglobulins – primary and secondary antibodies, cytoskeletal proteins, enzymes, lectins , receptors – types, nature and function - abzymes.

Nature, Properties and Function of Nucleic acids:Nitrogen bases-purines, pyrimidines, nucleosides and nucleotides – oligonucleotides - base paring – DNA, RNA-tRnNA,mRNA,rRNA, antisense RNA – linear and circular forms, single and double stranded– hypo and hyperchromicity - extra chromosomal DNA – mitochondrial,

choloroplastic, plasmid and viral – microsatellites – DNA varieties – A, B, and Z – Okazaki fragment –palindrome-concatenation- polymorphism – mutation – strand breaks – genes – promoters, enhancers, structural genes - gene expression – gene silencing - transposons – telomeres.

Nature, Properties and Function of Lipids: Fats, Oils, Waxes - Fatty acids – types, saturated, unsaturated, essential, short and long chain – triglycerides, lipids and cholesterol - fatty acid / triglyceride / cholesterol synthesis and degradation – alpha, beta and omega oxidation of fatty acids - membrane associated lipids – polar, non-polar, liposomes - fatty acid mobilization – lipid signaling molecules.

Biology of Cell and Cell Function: Types of cells – parenchyma, cholenchyma, sclerenchyma , glials, astrocytes, oligodendroglia, fibroblasts - Cell proliferation and differentiation - Cell division – pluripotency, totipotency, progenitor cells, differentiated cells, cancer cells, - sub cellular components –locomotion-chemoattractants–pinocytosis, phagocytosis –mitoses and meosis –membrane structure-membrane transport - nuclear transport - transcription, translation, transduction, conjugation – Cell communication and Cell signaling-hormones- cytokines-natural products.

Bioenergetics and Protein thermodynamics: High energy compounds – ATP, GTP – synthesis and utilization – reducing equivalents – chemiosmotic process – biochemical kinetics – forward and reversible reactions – reaction free energy – enthalpy - entropy - denaturation kinetics – Arrhenius plot.

Biocatalysis & Structural biology: Enzymes – active site, reaction rates, site specificity, sequence specificity, cofactor dependency, pH, temperature and ionic strength dependency – aqueous and organic phase catalysis - cryophilic, mesophilic and thermophilic enzymes – non protein enzymes –synthetic enzymes -enzyme classification - types of inhibition – enzyme immobilization - Industrial enzymes.

Books:

1. Harper's Biochemistry, 28th edition, Robert K Murray; Daryl K Garner; Peter A Mayes; Victor W Rodwell. Lange Medical Books/ McGraw Hill, New York.
2. Lehninger Principles of Biochemistry, 5th edition, David L Nelson; Michael M Cox. W.H.Freeman Publishers, New York.
3. Biochemistry, 3rd edition, Donald Voet and Judith Voet. John Wiley Publishers.
4. Cell & Molecular Biology, 8th edition, E.D.P.De Robertis. Lippincott publishers.
5. Molecular biology of the cell, 6th edition, Alberts. Garland Publishing.
6. Essentials of Molecular biology, David Freifelder, Jones & Bartlett Publishers.
7. Genes, 9th edition, Lewin Benjamin. CBS Publishers and Distributors.

8. Molecular Cell Biology, Harvey Lodish; David Baltimore; Arnold Berk. WH Freeman and Co.

6. NST-120: Laboratory, 4-Credits, 8 - hours per week

7. NST-126 NanoTechnology: Society and Environment , 1-Credit, 1 - hour per week

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.

Environmental effects of energy extraction, conversion and use-Sources of pollution; primary and secondary pollutants; Consequence of pollution growth; Air, water, soil, thermal, noise pollution- cause and effect; Causes of global, regional and local climate change; Pollution control methods; Environmental laws on pollution control. Global warming; Green House Gas emissions, impacts, mitigation; Zerovalent iron nanoparticles-titanium dioxide-silver nanoparticles-nanomembrane process-nanosorbants-mesoporous silica-ground water remedian-airpurifier-nano photocatalysis-nanocoating-corrosion prevention-nanosolar thermal absorber-nanobased environmental treatment.

NST-237	**Summer training (Report & Seminar)**	

IInd YEAR

Semester - III **Credits: 30**

Syllabai for courses

1. NST-231: Polymers and Nanocomposites 4-Credits, 4- hours per week

Principles, practice and mechanistic aspects of the synthesis of polymers and polymeric surfactants: Emulsion polymerisation, mini- and microemulsion polymerisation. Controlled architecture polymerisation and block copolymers – nitroxide mediated polymerisation, group transfer polymerisation, Physiochemical characteristics and properties of polymers and amphiphiles in solution: Theoretical and thermodynamic approaches. Behaviour of polymers in the dilute, non-dilute and concentrated regimes. Micellisation and phase behavior of amphiphiles. Properties and behaviour of polymers and amphiphiles at interfaces: polymeric surfactants, use of polymers and amphiphiles to control colloid stability Polymer – surfactant interactions: Specific examples, influence on phase behavior and micellisation. Hydrophobically associating polymers. Polymers and amphiphiles as performance chemicals - industrial applications and case studies: ink-jet printing, rotary and screen printing, electronics and displays technology, drug delivery, wound care, tissue engineering.

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.

Books:

1. Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V. Braun
2. Physical Properties of Carbon Nanotubes- R. Saito

2. NST-232: MEMS and NEMS, 4-Credits, 4- hours per week

Detailed modeling, analysis, and predictive design of micro- and nanoelectromechanical systems (MEMS and NEMS). Particular emphasis will be placed on the development of first-principles, multi-physics models capable of accurately capturing the behavior of micro/nanoscale devices. Model reduction methods will be introduced and subsequently exploited, in conjunction with a number of distinct analytical techniques, for predictive design purposes. The course will discuss a number of common micro/nanosystems, including the resonant and non-resonant inertial, pressure, and mass sensors, probe-based microscopes, and electromechanical signal processing elements.

Books:

1. J. A. Pelesko and D. H. Bernstein, *Modeling MEMS and NEMS*. 2002, Boca Raton, Florida: Chapman & Hall/CRC.
2. • A. N. Cleland, *Foundations of Nanomechanics: From Solid-State Theory to Device Applications*. Advanced Texts in Physics. 2003, Berlin: Springer.
3. • V. Kaajakari, *Practical MEMS*. 2009, Las Vegas, Nevada: Small Gear.
4. • C. Liu, *Foundations of MEMS*. Illinois ECE Series. 2006, Upper Saddle River, New Jersey: Pearson/Prentice Hall.

3. NSNT-233*: Elective – a, 4-Credits, 4- hours per week

4. NST-234*: Elective – b, 4-Credits, 4- hours per week

5. NST-235*: Elective – c, 4-Credits, 4- hours per week

6. NST-230: Laboratory, 4-Credits, 8 - hours per week

7. NST-236: NanoTechnology: Business Enterprise, Project management & Intellectual Property Rights, 1-Credit, 1 - hour per week

8. NST-237 : Summer training (Report & Seminar), 5-Credits

Semester - IV **Credits: 20**

1. NST-241: Project, 20 – Credits, One semester

*ELECTIVES (NST-233, NST-234 and NST-235):

1a. NST-233: Nano Electronics , Elective – a, 4-Credits, 4- hours per week

Module 1 (17 hours):
Scaled sub 100nm MOSFETs, challenges in miniaturization, quantum effects
Thin oxides, random dopant fluctuation, lithography, tunneling and subthreshold currents, power density, hot electron effects, fundamental limits of MOS operation, Charge and energy quantization.

Module 2(17 hours):
Novel Si-based MOSFETs and Carbon based FETs
Strained silicon, multigate MOSFETs, Silicon on Insulator devices, FinFETs, Silicon Nanowire based FETs, carbon nanotube and graphene based FETs.

Module 3 (17 hours):
Single electron, resonant tunneling, molecular and spintronic devices
Coulomb blockade, Coulomb staircase, Bloch oscillations, Resonant Tunneling diode and Resonant Tunneling Transistor, hybrid RTD–FET, Molecular Wires, Quantum-Effect Molecular Electronic Devices, Electromechanical Molecular Electronic Devices, spinFET characteristics.

Books:

1. Y. Taur and T. H. Ning, "Fundamentals of Modern VLSI devices", Cambridge University Press, 1998.

2. K Goser, P. Glosekotter, J. Dienstuhl, "Nanoelectronics and Nanosystems: from transistors to molecular and quantum devices", Springer, 2005.

3. M. Dragoman and D. Dragoman, "Nanolectronics - principles and devices", Artech House Publishers, 2005.

4. M. Lundstrom and J. Guo, "Nanoscale transistors – device physics, modeling and simulation", Springer 2005.

5. D. Goldhaber-Gordon et. al., "Overview of Nanoelectronic Devices", Proc. of IEEE, vol. 85, no. 4, April 1997.

1b. NST-234: Nanophotonics, Elective – b, 4-Credits, 4- hours per week

Fundamentals, Maxwell's equations, light-matter interaction, dispersion, EM properties of nanostructures, etc., Photonic crystals, Photonic crystal fibers, Photonic nanocircuits, Metal optics, Manipulating light with plasmonic

nanostructures, Plasmonic nano-sensors, Near-field optics, Metamaterials, negative refractive index and super-resolution.

Books:

1: Progress in Nano-Electro-Optics III Industrial Applications and Dynamics of the Nano-Optical System : Motoichi Ohtsu (Ed.) ISBN 3-540-21050-4 Springer Berlin Heidelberg New York 2005

2: Surface Plasmon Nanophotonics Mark L. Brongersma Pieter G. Kik (Ed) ISBN: 978-1-4020-4349-9 (HB) Springer 2007

3: Nanophotonic Materials Photonic Crystals, Plasmonics, and Metamaterials Edited by R. B. Wehrspohn, H.-S. Kitzerow, and K. Busch Wiley VCH Verlag GmbH & Co KGaA 2008

4: PLASMONICS: FUNDAMENTALS AND APPLICATIONS by STEFAN A. MAIER ISBN 978-0387-33150-8 Springer 2007

5: Optical Metamaterials Fundamentals and Applications by Wenshan Cai and Vladimir Shalaev ISBN: 978-1-4419-1150-6 Springer

1c. NST-235: Nanomagnetics, Elective – c, 4-Credits, 4- hours per week

Magnetic nanostructures: Particles and clusters Thin films and multilayers Nanowires Nanocomposites and other bulk materials
Atomic-scale effects Magnetic moment Magnetization and magnetic order Anisotropy Mesoscopic magnetism Phenomenology of hysteresis Micromagnetic background Fundamental magnetization processes Nucleation in nanocomposites and multilayers Grain boundaries and nanojunctions Textured magnets and random-anisotropy behaviour Magnetic localization and cooperativity of magnetization reversal
Magnetization dynamics Spin waves Magnetic viscosity and sweep rate dependence of coercivity Freezing behaviour

Books:

1. Skomski R and Coey J M D 1999 *Permanent Magnetism* (Bristol: Institute of Physics Publishing)
2. Craik D 1995 *Magnetism: Principles and Applications* (New York: Wiley)
3. Charles S W 1992 *Studies of Magnetic Properties of Fine Particles and their Relevance to Materials Science*
   ed J L Dormann and D Fiorani (Amsterdam: Elsevier)
4. Sellmyer D J, Luo C P, Qiang Y and Liu J P 2002 Nanomaterials and magnetic thin films *Handbook of Thin*
   Film Materials vol 5, ed H S Nalwa (San Diego, CA: Academic)
5. Ziese M and Thornton M J (ed) 2001 *Spin Electronics* (Berlin: Springer)
6. Skomski R, Liu J P, Meldrim J M and Sellmyer D J 1998 *Magnetic Anisotropy and Coercivity in Rare-Earth*
   Transition Metal Alloys ed L Schultz and K-H M¨uller (Frankfurt/M: Werkstoffinformationsgesellschaft)

7. McCurrie R A 1994 *Ferromagnetic Materials—Structure and Properties* (London: Academic)
8. Bland J A C and Heinrich B (ed) 1994 *Ultrathin Magnetic Structures* vol 1 (Berlin: Springer)
9. Jiles D 1998 *Introduction to Magnetism and Magnetic Materials* (London: Chapman and Hall)
10. Kittel C 1986 *Introduction to Solid-State Physics* (New York: Wiley)
11. Sutton A P 1993 *Electronic Structure of Materials* (Oxford: Oxford University Press)
12. Yeomans J M 1992 *Statistical Mechanics of Phase Transitions* (Oxford: Oxford University Press)
13. Smart J S 1966 *Effective Field Theories of Magnetism* (Philadephia, PA: Saunders)
14. Aharoni A 1996 *Introduction to the Theory of Ferromagnetism* (Oxford: Oxford University Press)
15. Rodewald W,Wall B, Katter M, U¨ stu¨ner K and Steinmetz S 2002 *Rare-Earth Magnets and their Applications (Proc. 17th REM)* ed G C Hadjipanayis and M J Bonder (Princeton, NJ: Rinton Press)
16. Evetts J E (ed) 1992 *Concise Encyclopedia of Magnetic and Superconducting Materials* (Oxford: Pergamon)

2. Materials Simulations

2a. NST-233: Density Functional Theory - *ab initio* methods, Elective – a,
4-Credits, 4- hours per week

Quantum theory of many electron systems - Hartree and Hartree Fock methods. Beyond Hartree Fock: Wavefunction expansion and perturbation methods. Hohenberg-Kohn theorems, Degenerate ground state, Kohn-Sham equations - Spin polarised systems, definition of exact exchange within DFT, Local density approximation, Nonlocal correlations to LDA, Generalized Gradient approximation, Self interaction correction, Pseudopotential theory, Understanding chemical bonding by DFT: Formation of water, Band structure calculations of bulks, Structure optimization, Band structure and density of states. Generalizations to include magnetic fields, DFT codes: All electron codes and pseudopotential codes - WIEN2k, SIESTA, ABINIT, VASP and CASTEP.

Books:

1. R.M. Dreizler and E.K.U. Gross, Density Functional Theory, (Springer, Berlin, 1990)
2. R.G. Parr and Q. Yang, Density Functional Theory of Atoms and Molecules, (Oxford Science Publications 1989)
3. R.M. Martin, Electronic Structure: Basic Theory and Practical Methods, (Cambridge University Press 2004)
4. D. Raabe, Computational Materials Science: The Simualtion of Materials Microstructure and Properties, (Wiley-VCH, 1998)
5. J.D. Hill, L. Subramaiah and A.Maiti, Molecular Modeling Techniques in Material Science, (Taylor and Francis, 2005)
6. M. Meyer and B. Pontikis, Computer Simulation in Material Science: Inter-atomic Potentials, Simulation, Techniques and Applications, (Kluwer Academic,1991)
7. K. Ohno, K. Esfarjani and Y.Kawazoe, Introduction to Computational Material Science: from *ab initio* to Monte Carlo methods, (Springer-Verlag, 1999)

2b. NST-234: Molecular Dynamics and Monte Carlo Simulations, Elective – a,
4-Credits, 4- hours per week

Euler, Verlet and Velocity-Verlet integrators for Newtons equations for MD, Interaction potential including long range interactions, Energy minimization techniques, Constant energy and constant temperature simulations, Free energy calculations, Statistical mechanics and treatment of simulation data, Visualisation of structure and data, Electronic degrees of freedom: Car - Parinello method.

Monte Carlo Simulation, Markov Chain, Metropolis Algorithm, Configuration Bias Monte Carlo method, Wang Landau algorithm to compute density of states, Kinetic Monte Carlo Simulations: Coarse grained atomic simulations.

Books:

1. D.W. Heerman, Computer Simulation Methods, (Springer-Verlag, 1986)
2. M.P. Allen and D.J. Tildesley, Computer simulation of Liquids, (Oxford U. Press, New York, 1989)

2c. NST-235: Continuum Simulations and Multiscale Modeling, Elective – a,
4-Credits, 4- hours per week

Finite Difference, Finite Volume and Finite Element methods, FDTD method to Computational Eelectrodynamics, Applications of FEM methods in material science: impedance effects at point contacts, Computational fluid dynamics: Using codes - FLUENT, PHENIX, Multiscale Modeling: Quasicontinuum method to integrate the atomistic and continuum scales. Modeling dislocation behavious, Phase field modeling, Modeling of grain growth and microstructure.

Books:

1. Z. Xiao Guo (Ed), Multiscale Materials Modeling: Fundamentals and Applications, Woodhead Publishing Ltd. (Cambridge, 2007)
2. Zoe H. Barber, Introduction to Materials Modeling, (Maney Publishing, 2005)

3. NanoBioelectronics

3a. NST-233: Genomics and Proteomics, Elective – a, 4-Credits, 4- hours per week

Genomic studies: What Is Genomics? - Family Pedigree - Karyotyping and Linkage Analysis - DNA Sequence Analysis - Whole Genome Sequencing- How Are Organisms Picked for Genome Sequencing? - Unicellular Genomes.

Techniques in genomics: Gene analysis – Southern blotting - Genome Expression – PCR and variants – Real-time PCR – DNA Microarrays – Log transformation of Microarray – Expression Profile sharing.
Chromosomes and their function: Chromosomes - Chromatin – Chromatids – Histones – DNA double helix – Modifications – Prokaryotic and Eukaryotic genome – Euchromatin

and Heterochromatin - Mendelian, non Mendelian and Sex linked inheritances – chromosomal translocations.

Molecular biology of the gene: DNA replication – Conservative, Semi conservative, Rolling circle and Cairn's model – mechanism of -Types of mutations – Induced, Reverse – Suppressor, Spontaneous – Site directed mutagenesis - Mutagens – intercalators – DNA damage and Repair Processes – photoreactivation, excision, recombinational, SOS, Cloning- methods – Genomic libraries.

Proteomic studies: Introduction to Proteomics. - Branches of proteomics: Protein separation, Protein identification, Protein quantification, Protein sequence analysis, Structural proteomics, Interaction proteomics, Protein modification, and Cellular proteomics. Sample handling and storage: Preparation of Sample, Subcellular fractionation, Density gradients, Affinity, Protein fractionation, Ultrafiltration. Purification: Removal of interfering compounds, Salts, DNA, Lipids, Protein solubilisation, Disulphide bonds, chaotropes, detergents, etc. Detection and quantitation: Chemical tagging, fluorescence, negative staining, Radio-labelling.

Protein Expression and Interactions: Protein expression systems: transfection, transformation, transduction, induction, detection and purification of expressed transgenes - Protein/peptide chemical synthesis. Protein interactome - Methodology for detection, protein-protein interactions. Protein arrays - protein polynucleotide interactions, interactions with other biomolecules, Signaling complex - Protein microarrays - Merits and demerits of DNA and protein microarrays.

Protein profiling in health and disease: Body fluids, Lipid & Kidney, Blood diseases, Diabetes, Infectious diseases, Stroke & Myocardial infarction, Nervous system, Alzheimer, Low abundance and hydrophobic proteins, High throughput techniques to identify proteins in samples.

Books:

1. Discovering genomics, Proteomics and Bioinformatics, 2nd edition, A Malcolm Campbell and Lurie J Heyer. Benjamin Cummings publishers.
2. Principles of Proteomics, R.M.Twyman. BIOS Scientific Publishers.
3. Proteomics: Methods and Protocols, Jorg Reinders and Albert Sickmann. Springer Protocols, Humana Press.
4. Proteomics in practice: A Guide to successful experimental design, Reiner Westermeier; Tom Naven and Hans-Rudolf Hopker. Wiley-VCH publishers.
5. Introduction to Genomics, Arthur Lesk. Oxford University Press, USA.
6. Bioinformatics and Functional Genomics, Jonathan Pevsner. Wiley-Blackwell Publishers.
7. Introduction to Computational Genomics: A Case Studies Approach. Nello Cristianini and Matthew W Hahn. Cambridge University Press.

8. Principles of Gene Manipulation and Genomics. Sandy B Primrose and Richard Twyman. Wiley-Blackwell Publishers

3b. NST-234: BioElectro Mechanics, Elective – b, 4-Credits, 4- hours per week

The cell and its functions: Organization, physical structure, locomotion of cells. Membrane Physiology, Nerve, and Muscle: Transport of Substances Through the Cell Membrane, Membrane Potentials and Action Potentials, Contraction of Skeletal Muscle, Excitation of Skeletal Muscle, Neuromuscular Transmission and Excitation-Contraction Coupling, Contraction and Excitation of Smooth Muscle. The nervous system: Organization, sensory receptors, motor and integrative neurophysiology. Electromechanics of Cardiac System: Absorption of Electromechanical Energy: Electrodynamic Energy, Mechanical Energy – Ultrasonic Energy, Mechanical Resonances of Biological cells. Biomachines: Actin-Myocin Machine, Living Machines, Amorphous and Cellular Computing.

Books:

1. Medical Physiology by Arthur C. Guyton
2. Ref: for Biomachines: http://www.ai.mit.edu/research/abstracts/abstracts2001/bio-machines/bio-machines.shtml ,
3. The Once and Future Nanomachine: Scientific American Vol. 285, No. 3 (September 16, 2001), pgs. 78-83.

3c. NST-235: Bioelectronic Devices, Elective – c, 4-Credits, 4- hours per week

Bioelectric signals and their recording: Bioelectric signals (ECG, EMG, ECG, EOG, EGG & ERG) and their characteristics, Mechanisms of Electrodermal activity (GSR), Bioelectrodes, electrodes tissue interface, contact impedance, effects of high contact impedance, types of electrodes, electrodes for ECG, EEG and EMG. Transducers for Biomedical Application: Resistive transducers - Muscle force and Stress, Spirometry, humidity, Respiration, Inductive Transducers - Flow measurements, muscle movement, Capacitive Transducers - Heart sound measurement, Pulse pick up, Photoelectric Transducers - Pulse transducers, Blood pressure, oxygen Analyses, Piezoelectric Transducers - Pulse pickup, ultrasonic blood flow meter, Chemical Transducer. Bioldectric Signal recording machines: Physiological pre-amplifier and specialized amplifiers, ECG lead systems details of ECG, EMG, GSR, EGG, and EEG machines. Safety Aspect of bioelectric instruments: Gross current, Micro Current shock, safety standards rays and considerations, safety testing instruments, biological effects of X-rays and electromagnetic radiations and precautions.

Books:

1.Medical Instrumentation by John. G. Webster –John Wiley
2. Principles of Applied Biomedical Instrumentation by Goddes & Baker – John Wiley
3. Biomedical Instrumentation & Measurement by Carr & Brown-Pearson
4. Biomedical Instrument by Cromwell-Prentice Hall of India, New Delhi
5. Hand book of Medical instruments by R.S. Khandpur –TMH, New Delhi

6. Medical Electronics and Instrumentation by Sanjay Guha – University Publication
7. Introduction to Biomedical electronics by Edwand J. Bukstein –sane and Co. Inc. USA

6. NST-230: Laboratory, 4-Credits, 8 - hours per week

This Course discusses working principles materials, configuration and performance specification of micro transducers based on MEMS technology .On these basis, experiments using mechanical, electrical ,optical, thermofluidie and biochemical microtransducers are provided.

7. NST-236: NanoTechnology: Business Enterprise, Project management & Intellectual Property Rights , 1-Credit, 1 - hour per week

Nanotechnology is differentiated from the other major technologies like IT and Biotechnology by its far more interdisciplinary nature and its broader sphere of impact. Nanotechnology potentially affects very large product delivery supply-chain and therefore requires a greater degree of understanding and integration and customer base to extract maximum benefit. Basics of Program Evaluation & Review Techniques (PERT) and Critical Path Method (CPM).

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.

FACILITIES REQUAIRED

I. Chemical sysnthesis:

1. Fume Hoods – 3
2. Magnetic stirres – 5
3. Heating Mantles – 5
4. Rotory Pumps – 3
5. Rotory Evaporators – 3
6. Auto Claves – 3
7. Microwave Ovens - 2
8. Microwave Ovens with hydrothermal facility - 2
9. Milli--- Distilled water platnt – 1
10. Spin Coaters – 3
11. Langmuir Bladgett films
12. Furnances – 6 (900 ^{O}C -2, 1200 ^{O}C - 2, 1600 ^{O}C-1, 2500 ^{O}C – 1
12. Ovens – 6
13. Vacuum Ovens – 3
14. Humidity chambers -3
15. High and Ultra High speed Cetrifuge Systems -3 (each one)
16. Ultra High frequency sonicators – 3
17. Laminar flow -3
18. Pelletizer with Dies - 3
19. Glass wares
20. Chemicals
21. Crucibles, Boats

Some to be added

II.Physical synthesis Methods:

1. Ball Mills - 2
2. RF with Magnetron Sputtering – 1
3. Chemical Vapour Deposition - 1
4. Pulsed Laser depostion
5. Electron Beam / SEM Lithography - 1

III. COMPUTER LAB

1. High power computing system with 20- PC terminals and one networking Printer for Simulation Lab

IV. Characterizations and Measurments

1. TEM-EDS
2. FE - SEM-EDS
3. SPM
4. XRD
5. FTIR
6. Confocal microscope with Raman spectrometer
7. TG/DTA and DSC
8. NMR (solid state)
9. UV-Vis
10. Particle size analyzer
11. Surface area and pore analyzer (BET)
12. Polarisng Microscope
13. Magnetic conductivity system
14. Impedance – EIS
15. Ultra fast laser system
16. Thermal Conductivity
17. Density meter (Pycnometer)
18. Microhardness and Nanoindendtation
19. Thermal expansion
20. Four Probe conductivity set up with current and voltage source cum measuring meters
21. Hall effect
22. Photoconductivity
23. Solar cell characterization set up
24. Battery characterization set up
25. Sensor characterization set up
26. Fuel Cell characterization set up
27. Nano Indentation
28. Ellipsometry
29. Near field Optical Microscopy (NSOM)
30. Clean room
31. Simulation Lab

IV. Staff Requirement

1. 2 - Lab Technicians for Synthesis Lab
2. 2 - Lab Technicians for Simulation Lab
3. 2 - Lab Technicians for Instrumentation Lab
4. 3- Lab Assistants (one for each Lab)

5. 1- Junior Assistant
6. 1- Office attender

V. Space Requirement

1. Synthesis Labs – 1 (20 x 20)
2. Simulation Lab – 1 (20 x 20)
3. Instrumentation Lab – 1 (20 x 20)
4. Teaching class rooms -1 (20 x 20)
5. Coordinator room – 1
6. Office room – 1