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.


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

<table>
<thead>
<tr>
<th>Semester</th>
<th>Credits</th>
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<tr>
<td>1.</td>
<td>25</td>
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<tr>
<td>1.</td>
<td>NST-111</td>
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<td>NST-112</td>
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<td>3.</td>
<td>NST-113</td>
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<td>NST-114</td>
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<td>NST-115</td>
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<td>6.</td>
<td>NST-110</td>
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<td>7.</td>
<td>NST-116</td>
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<tr>
<th>S. No.</th>
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<th>Title of the course</th>
<th>Credits</th>
<th>Remarks L/T/P</th>
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<tr>
<td>1.</td>
<td>NST-121</td>
<td>Physical Properties of Nanomaterials</td>
<td>4</td>
<td>4/0/0</td>
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<tr>
<td>2.</td>
<td>NST-122</td>
<td>Self Assembly of Nanostructures</td>
<td>4</td>
<td>4/0/0</td>
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<tr>
<td>3.</td>
<td>NST-123</td>
<td>Nanostructures: Modeling, Design &amp; Simulations</td>
<td>4</td>
<td>4/0/0</td>
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<tr>
<td>4.</td>
<td>NST-124</td>
<td>Nanocatalysis and Colloidal Systems</td>
<td>4</td>
<td>4/0/0</td>
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<tr>
<td>5.</td>
<td>NST-125</td>
<td>Biology for Nanosciences</td>
<td>4</td>
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<td>6.</td>
<td>NST-120</td>
<td>Laboratory</td>
<td>4</td>
<td>0/0/8</td>
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<td>7.</td>
<td>NST-126</td>
<td>NanoTechnology: Society and Environment</td>
<td>1</td>
<td>1/0/0</td>
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<td><strong>Total Credits</strong></td>
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NST-237  **Summer training (Report & Seminar)**
IIInd YEAR

Semester - III

<table>
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<tbody>
<tr>
<td>1.</td>
<td>NST-231</td>
<td>Polymers and Nanocomposites</td>
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<td>2.</td>
<td>NST-232</td>
<td>MEMS and NEMS</td>
<td>4</td>
<td>4/0/0</td>
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<td>NST-233</td>
<td>Elective – a</td>
<td>4</td>
<td>4/0/0</td>
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<td>4.</td>
<td>NST-234</td>
<td>Elective – b</td>
<td>4</td>
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<td>5.</td>
<td>NST-235</td>
<td>Elective – c</td>
<td>4</td>
<td>4/0/0</td>
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<td>6.</td>
<td>NST-230</td>
<td>Laboratory</td>
<td>4</td>
<td>0/0/8</td>
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<tr>
<td>7.</td>
<td>NST-236</td>
<td>NanoTechnology: Business Enterprise,</td>
<td>1</td>
<td>1/0/0</td>
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<td></td>
<td></td>
<td>Project management &amp; Intellectual Property Rights.</td>
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<tr>
<td>8.</td>
<td>NST-237</td>
<td>Summer training (Report &amp; Seminar)</td>
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<td><strong>Total Credits</strong></td>
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Semester - IV

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<th>Title of the course</th>
<th>Credits</th>
<th>Remarks</th>
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<tr>
<td>1.</td>
<td>NST-241</td>
<td>Project</td>
<td>20</td>
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<td><strong>Total Credits</strong></td>
<td><strong>20</strong></td>
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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

1st 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


Review of Electromagnetic Theory:

Books:
1. Quantum mechanics, Ghatak & Loganathan, McMillan
2. Quantum mechanics, L. I. Schiff
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
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


Books:
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.


Books:

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, Photoacoustic 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.


Books:

10. Processing & properties of structural naonmaterials - Leon L. Shaw (editor)

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


   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

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

**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:

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


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


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


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


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:

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


Books:
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.

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<th>NST-237</th>
<th>Summer training (Report &amp; Seminar)</th>
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IIInd YEAR

Semester - III Credits: 30

Syllabai for courses

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


Metal based nanocomposites- Metal-Oxide or Metal-Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality. Metal-metal

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:

3. V. Kaajakari, Practical MEMS. 2009, Las Vegas, Nevada: Small Gear.

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**

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<td>NST-241</td>
<td>Project</td>
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**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:**


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:


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:

2. Materials Simulations

2a. NST-233: Density Functional Theory - \textit{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:

5. J.D. Hill, L. Subramaiah and A.Maiti, Molecular Modeling Techniques in Material Science, (Taylor and Francis, 2005)
7. K. Ohno, K. Esfarjani and Y.Kawazoe, Introduction to Computational Material Science: from \textit{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)

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 Electrodynamics, 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 behaviours, Phase field modeling, Modeling of grain growth and microstructure.

Books:
3. NanoBioelectronics

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


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.


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 quantitiation: 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:
5. Introduction to Genomics, Arthur Lesk. Oxford University Press, USA.

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


Books:

1. Medical Physiology by Arthur C. Guyton

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. Bioelectrical 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:

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. 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, thermofluidic 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 REQUIRED

I. Chemical synthesis:
1. Fume Hoods – 3
2. Magnetic stirres – 5
3. Heating Mantles – 5
4. Rotary Pumps – 3
5. Rotary 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 °C -2, 1200 °C - 2, 1600 °C-1, 2500 °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 deposition
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 Measurements

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. Polarising Microscope
13. Magnetic conductivity system
14. Impedance – EIS
15. Ultra fast laser system
16. Thermal Conductivity
17. Density meter (Pycnometer)
18. Microhardness and Nanoindentation
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