



**M.TECH – NANO TECHNOLOGY
 (TWO YEAR FULL TIME)
 CURRICULUM 2008
 SEMESTER – I**

Code No.	Course Title	L	T	P	C
THEORY					
YNT101	Mathematical methods	4	1	0	4
YNT102	Introduction to Quantum Mechanics	3	1	0	4
YNT103	Introduction to Nanoscience & Nanotechnology	3	1	0	4
YNT104	Basic of Computer Programming and Computation numerical analysis	3	1	0	4
YNT105*	Elective – I	3	1	0	3
YNT106*	Elective – II	3	1	0	3
PRACTICAL					
YNT107	Computer Simulation Lab – I	0	0	3	3
YNT108	Nanotechnology Lab – I	0	0	3	3

Total Hours:31

Total Credits: 28

SEMESTER II

Code No.	Course Title	L	T	P	M
THEORY					
YNT201	Principles of Biotechnology	4	0	0	4
YNT202	Principles of Nanoheterostructures	4	0	0	4
YNT203	Simulation methods and techniques	4	0	0	4
YNT204	Fabrication Technique & Analytical instrumentation for nanomaterials	4	0	0	4
YNT205*	Elective – III	4	0	0	3
YNT206*	Elective – IV	4	0	0	3
PRACTICAL					
YNT207	Computer Simulation Lab – II	0	0	3	3
YNT208	Nanotechnology Lab – II	0	0	3	3

Total Hours:31

Total Credits:28

SEMESTER III

Code No.	Course Title	L	T	P	M
Practical					
YNT301	Project Work (Phase I)	0	0	25	10

Total Hours:25

Total Credits:10

SEMESTER – IV

Code No.	Course Title	L	T	P	M
YNT401	Project Work (Phase II)	0	0	25	12

Total Hours:25

Total Credits:12

Overall Credits:78

LIST OF ELECTIVES

Code No.	Course Title	L	T	P	M
Elective-I					
YNT105A	Properties of Nanophase materials	3	0	0	3
YNT105B	Processing Technology of MEMS & NEMS	3	0	0	3
YNT105C	Nanofluid Dynamics	3	0	0	3
YNT105D	Nanobiotechnology	3	0	0	3
Elective-II					
YNT106A	Molecular Nano electronics	3	0	0	3
YNT106B	Functional Structure & Mechanics (Carbon Nanotubes)	3	0	0	3
YNT106C	Biosensors & Biomarkers	3	0	0	3
YNT106D	Nanomanipulation & Assembly	3	0	0	3
Elective-III					
YNT205A	Design & Simulation of MEMS & NEMS	3	0	0	3
YNT205B	Self Assembling Nanostructured Molecular Material & Devices	3	0	0	3
YNT205C	Semiconductor Nanoclusters & Nanoparticles	3	0	0	3
YNT205D	Nano particles, Micro-organisms & Biomaterial Hybrid Systems	3	0	0	3
Elective-IV					
YNT206A	Nanomedicine	3	0	0	3
YNT206B	Applications of Nanomaterials in Energy conversion process	3	0	0	3
YNT206C	Photonics	3	0	0	3
YNT206D	Societal Dimensions of Nanotechnology	3	0	0	3

UNIT I : Vector calculus 9

Idea of curvilinear co-ordinates, various orthogonal systems; Cartesian, spherical, cylindrical, concept of vector differentiation, gradient of a vector, curl of a vector, the concept of the line, surface and volume integral, Gauss's and Stake's theorems.

UNIT II : Elements of complex variables 9

Analyticity of complex functions, Cauchy-Riemann conditions, Cauchy's residue theorem, Cauchy principal value, evaluation of definite integrals, Jordon's Lemma and its applications.

UNIT III : Theory of transforms 9

Fourier sine, cosine and complex transforms, transforms of derivatives, convolution theorem, Parseval's relation, momentum representation ; example from optics, electromagnetism and quantum mechanics, Laplace transforms of simple function and derivatives, LT solution of simple differential equation, convolution theorem.

UNIT IV : Special functions-I 9

Singularity structure of a general second order homogeneous differential equation; ordinary point, regular point and irregular points, indicial equation, the point of infinity, series expansion method for solving differential equations, occurrence, of Bessel and Hermite differential equations in physical problems, series solutions, recurrence relations, generating function, RodrigueZ formula, orthogonality of Bessel function and Hermite polynomial.

UNIT V : Special functions-II 9

Series solutions, recurrence relations, generating function and orthogonality of Legendre and Laguerre polynomials, Hypergeometric equation and Hypergeometric functions, confluent hypergeometric equation and corresponding functions, representation of various functions in terms of hypergeometric functions.

L:45; T:15; Total : 60

TEXT & REFERENCES :

1. Introduction to Mathematical Physics, Charlie Harper, Prentice-Hall, 1976.
2. Applied Mathematics for Engineers and Physicist Louis Albert Pipes, Lawrence R. Harvill, McGraw-Hill, 1970.
3. Vector Calculus, Complex Variables, Transforms and Differential Equations, Schaum out line Series .
4. Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley & Sons, Published 2005

UNIT I : Formalism of quantum mechanics 9

Basic postulates of quantum mechanics, equation of continuity, normalization, orthogonality and closure properties, of eigen functions, expectation values and Ehrenfest theorem, box normalization, Dirac delta function and its properties, concept of Hilbert space, change of basis and Unitary transformations, Schrödinger and Heisenberg interaction representation. Introduction to angular momentum operators: eigen values & eigen vectors of L^2 , L_z , spin & J^2 & J_z .

UNIT II : One, Two & Three dimensional problems 9

Solution of one dimension Schrodinger for (a) potential step, (b) potential well (infinite as well as finite), (c) potential barrier & tunneling (transmission & reflection coefficients) (d) linear harmonic oscillator (e) one dimensional hydrogen atom Solution of two dimensional Schrodinger using Cartesian, spherical and cylindrical coordinators with application to two dimensional harmonic oscillator and hydrogen atom (bound & scattering states).

Solution of three dimensional Schrodinger for (a) harmonic oscillator (b) hydrogen like atom (c) rigid rotator (d) square well potential.

Note : In each case (a), (b) & (c) above, suitable applications are to be discussed with reference to quantum hetrostructures.

UNIT III : Approximation methods I (time independent) 9

Non-degenerate and degenerate perturbation theory with applications to quantum, hetrostructures (quantum well/ quantum wire/ quantum dot) variational approximation & WKB method with suitable application.

UNIT IV : Approximation methods II (time dependent) 9

Formulation of time dependent perturbation for constant and harmonic perturbation, transition probability, and Fermi Golden rule, atoms in a radiation field, emission and absorption of radiation, selection rules.

UNIT V : Approximation methods II I (many particle systems) 9

Statistical methods, mean field approximation, Hartree and Hartree- Fock approximation, basics of density functional formulism, molecular dynamics.

Total: 45

TEXT & REFERENCES:

1. Quantum Mechanics (International pure and Applied Physics), L.I. Schiff, McGraw Hill, Third Edition, 1968.
2. Quantum Mechanics : John L. Powell, Bernd Crasemann, Addison-Wesley Publications, Published 1961
3. Introduction to Quantum Mechanics with applications to Chemistry, By Linus Pauling, Edgar Bright Wilson, Courier Dover, Publications, Published 1985.
4. Quantum Mechanics, Theory and Applications, Ajoy.K.Ghatak and S.Lokanathan, Springer, Published 2004.

UNIT I : Emergence of Nanostructures 9

Historical Development : emergence of nanotechnology with special reference to Feynman & Drexler; Size & Scales : Spatial and temporal scales ; concept of confinement : strong & weak confinements with suitable examples ; Discovery and development of quantum heterostructures : Quantum well, quantum wire and quantum dot (The unit is completely qualitative, hence the concepts one to be developed with the help of suitable examples without going into mathematical/experimented details).

UNIT II : Nanoscale Phenomena 9

Density of states, tunneling, chemical bonds (types & strength), Intermolecular force, Molecular and crystalline structures, Hierarchical structures and Functionality, Surfaces and Interfaces, Casimir force, Bulk to surface transition, Self assembly and surface reconstruction.

UNIT III : Classification of Functional Nanomaterials 9

(Synthesis, properties and applications (phenomenological description only no detailed derivations) Inorganic nanomaterials : buckyballs Fullerene, carbon nanotube including polymers, monomers, amorphous, crystallite, semicrystallite, crystals, polycrystals, liquid crystals, composite materials : ceramic alloys, silicates), quantum heterostructures : quantum well, quantum wire, quantum dot, nanofossils & nonporous inorganic materials.

Organic nanomaterials : Dendrimers, micelles, liposome's, block copolymers.

Bionanomaterials : Biomimetic Systems, bioceramics & nanotherapeutics
Nanomaterials for molecular electronics and optoelectronics : thin film transistor, Single electron transistor, light emitting devices, photovoltaic nanomagnetic materials and nanosuperconductors.

UNIT IV : Structures of materials 9

Particle, wires, rods, clusters, solid solutions, details of crystal structure; crystal plane, Miller indices, classification of crystal (symmetry group classification), crystal orientation, morphology of material. Mechanical properties: hardness, compressive and tensile strength, electronic, thermal conductivity and optical absorption.

Imperfection in solids : Grain boundaries their relation to mechanical properties, dislocations in single crystals (linear defects and screw dislocation), imperfection dependent properties of crystals.

UNIT V : Applications of Nanomaterials 9

Applications of nanomaterials in sensors, clothes/ paints health care, electronics, computer and other industrial as well as consumer products. (The unit is aimed to provide an overview of various applications of nanomaterials.)

Total : 45

TEXT & REFERENCES :

1. Handbook of Nanotechnology, Bharat Bhushan, Springer, 2nd Edition, 2006.
2. Nanotechnology, J. Michael Köhler, Wolfgang Fritzsche, Wiley-VCH, (2004).
3. Introduction to Nanotechnology, Frank J. Owens, Charles P. Poole, Wiley-IEEE, (2003).
4. Encyclopedia of Nanoscience & Nanotechnology, Hari Singh Nalwa, American Scientific Publishers, Published 2004

UNIT I :Introduction to operating systems and Mat lab 9

Familiarization of various tools and environments, practical approach to learning operating systems and (DOS, UNIX, WINDOWS, LINUX) and graphical packages (Origin, Gun plot), LATEX, Internet.

Mat lab; running Mat lab, numerical calculations, graphics, 3D plots, equation solving, matrices, mathematical relations, complex numbers, simplifications, algebraic expressions, mathematical operations, inbuilt functions, differentiation, integration, series, limits.

UNIT II :Mat Lab 9

Running Mat Lab, numerical calculations, graphics, 3D plots, equation solving, matrices, mathematical relations, complex numbers, simplifications, algebraic expressions, mathematical operations, inbuilt functions, differentiation, integration, series, limits.

UNIT III :Computer programming (taking C and its extension to C++ ,as base) 9

Character set, variables, constants, data types, and their declarations, relational operator, logical operator, arithmetic operator, inbuilt functions, input output statements, functions, subroutines, array handling, pointers and classes.

UNIT IV :Numerical methods I 9

Matrices, solution of system of linear equations, direct methods, error analysis, curve fitting, iteration methods, quadrature formula, and numerical methods for ordinary differential equation, stability and convergence.

UNIT V :Numerical methods II 9

Interpolation, extrapolation, numerical solution of partial differential equation, initial value problem, random numbers, Monte Carlo integral methods, importance sampling, fast Fourier transforms.

Total: 45

TEXT & REFERENCES :

1. Numerical Analysis : S. S. Sastray, Prentice Hall of India, Published 2006.
2. Computer Based Numerical Methods : V. Rajaraman, Third Edition, Prentice Hall of India, Published 2004.
3. Programming in ANSI C : E. Balaguruswamy, Tata McGraw-Hill, New Delhi, 2004
4. Fortran Programming : V. Rajaraman, 4th Edition Prentice Hall of India, 2004.
5. Numerical Methods, A Computer Oriented Approach, RR.Salaria, BPB Publications, New Delhi, 1996.
6. Mat Lab Manual.
7. A Guide to Monte Carlo Simulations in Statistical Physics, David P. Landau, K. (Kurt) Binder, Cambridge University, Press Published 2005.
8. Numerical Recipes in C: The art of Scientific Computing, William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery, Cambridge University Press.
9. An Introduction to Computer Simulation Methods: Harvey Gould, Jan Tobochnik, Wolfgang Christian, Pearson Addison Wesley, Published 2006.
10. Computational Physics : S.E.Koonin, Benjamin/Cummins (1986).

1. Programming in C, C++ and Java.
 - Numerical Simulation. (Using C, C++)
 - Nano structures design (using Java)
2. Programming Using Mat Lab / Scilab.
 - Solving Quantum Mechanical problems.
3. Filter design-using OPAMP.

Total: 45

YNT108 NANOTECHNOLOGY LAB-I

0 0 3 3

1. Band gap Measurement.
2. Masking, Etching (PCB), Screen and lithographic printing
3. Nano Particle measurement.
4. Spray coating of Oxide materials

Total:45

UNIT I: Cell structure and physiology 9

Cell structure, function and types, cell multiplication, biomolecules; carbohydrates, proteins, lipids, nucleic acids, cellular metabolism; energy yielding and energy requiring pathways, transport of nutrients across, cell membrane.

UNIT II: Microbes 9

Structure, growth, isolation, preservation, DNA replication, genetic recombination.

UNIT III: Enzymology 9

Classification, kinetics, mechanism of action, purification, application.

UNIT IV: Immunology 9

Cell and organs of immune system, antigen and antibodies, cell mediated immunology, culturing of cells, stem cells, immunodiagnostics, cancer, graft rejection.

UNIT V: DNA technology 9

Restriction enzymes, Gene cloning technology, PCR, DNA probes, DNA sequencing, oligonucleotide synthesis, DNA microarray system.

Total:45**TEXT & REFERENCES**

1. Principles of Biochemistry : Albert L. Lehninger,, David L. Nelson, , Michael M. Cox, Worth Publishers, Published 1993.
2. The Cell : Carl Pontius Swanson, Peter L. Webster, Prentice Hall, Published 1977.
3. Microbiology :Lansing M. Prescott,, Donald A. Klein, John P. Harley , Wm. C. Brown Publishers, Published 1996.
4. Immunology : Janis Kuby, W.H. Freeman, Published 1992.
5. Molecular Biotechnology : S. B.Primrose, Blackwell Scientific, Published 1991.

UNIT I: Quantum heterostructures 9

Electronic structure of quantum dots, quantum wires and quantum well, confinement of electrons, energy quantization, semiconductor nanocrystals / carbon nanotubes / quantum well.

UNIT II: Quantum Transport Phenomena (Electrical) 9

Transport properties of quantum dots and quantum wires, quantization of conductance, density of states, coulomb blockade, kondo effect.

UNIT III: Thermal And Mechanical Properties Of Quantum Heterostructures 9

Vibrational and thermal properties of low-dimensional properties, phonons, quantization of phonon modes, heat capacity and thermal transport, nanomechanics and elastic properties, nanofluid mechanics; flow of nanofluids, surface tension.

UNIT IV: Nano-Optics 9

Introduction to nano-optics; overview and general theory, Light detection in nano-structures; scanning near-field microscopy, single-molecule detection, Optical properties; optics in nano-sized particle, optical quantum wells and wires, optics in periodic nano-structures, theory, special phenomena in 2D structures, microwave induced transport.

UNIT V: Nano-Electronics 9

Semiconductor nanoelectronic devices; Quantum dot, quantum wires, microwave induced transport, Spintronics; spin injection, spin valve effect, Molecular electronics; necessity, organic semiconductor, molecular switches, contact issues.

Total : 45

TEXT & REFERENCES :

1. Introduction to Nanotechnology , Frank J. Owens, , Charles P. Poole, Wiley-IEEE, (2003).
2. Encyclopedia of Nanoscience & Nanotechnology, Hari Singh Nalwa, American Scientific Publishers, Published 2004.
3. Microwave Properties of Magnetic Films : Carmine Vittoria, World Scientific, Published 1993.
4. Physics of Magnetism : S. Chikazumi with SH Charap, Krieger Publishing Company.
5. Physical theory of Magnetic Domains : C. Kittel.

YNT203 SIMULATION METHODS AND TECHNIQUES 4 0 0 4

UNIT I: Basics of simulation 9

Simulation; a concept and a tool of various techniques of simulation, simple approaches through CAD and CAM (only operational rules no details)

UNIT II: Physical simulation I 9

N body methods and particle simulations, verlet algorithm, molecular dynamics and Monte-Carlo methods, simulation for small system, Ab Initio methods.

UNIT III: Physical simulation II 9

Density function theory, mean field approximation, statistical methods for many body system, Hartree and Hartree Fock methods (the emphasis is on working rule. Hence detailed derivations are to be avoided. The applications are to be from nanostructures.).

UNIT IV: Advanced mathematica 9

Procedural programming, loops, conditional programming, producing output, linking external programming, functional programming, numerical operation on data, statistical calculations, minimization, derivatives of unknown functions.

UNIT V : Simulation algorithms 9

In this UNIT the student is required to develop an algorithm supported with flow chart taking example for the topics from (but not limited to) nanomaterials.

Total : 45

TEXT & REFERENCES:

1. Computer Based Numerical Methods : V. Rajaraman, Third Edition, Prentice Hall of India, Published 2004.
2. Mathematica : Stephen. Wolfram, Cambridge University Press, Published 1999.
3. A Guide to Monte Carlo Simulations in Statistical Physics, David P. Landau, K. (Kurt) Binder, Cambridge University Press, Published 2005.
4. Numerical Recipes in C: The art of Scientific Computing, William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery, Cambridge University Press.
5. An Introduction to Computer Simulation Methods: Harvey Gould, Jan Tobochnik, Wolfgang Christian, Pearson Addison Wesley, Published 2006.
6. Computational Physics : S.E.Koonin, Benjamin/Cummins (1986).

UNIT I : Top-down & Bottom-up techniques 9

Photolithography, other optical lithographies (EUV, X-ray, LIL), p beam lithographies (e-beam, FIB, a shadow mask evaporation), pr lithographies. Self-assembly, self-assembled monolayers, directed assembly, la by-layer assembly, (Material deposition methods : pattern definition, pallsin transfer, atomic and molecular manipulation).

UNIT II : Pattern replication techniques : Pattern transfer and enhancement techniques 9

Soft lithography, nanoimprint lithography, Wet etching, dry etching (isotropic, anisotropic), pattern growth techniques (polymerization, directed assembly).

UNIT III : Scanning microscopy & Spectroscopic characterization techniques 9

Scanning probe, SEM, TEM, STM, AFM, optical microscope, their description, operational principle and application for analysis of nanomaterials, UV-VIS-IR spectrometer and principle of operation and application for band gap measurements.

UNIT IV : Structural analysis techniques & X-ray spectroscopy for chemical analysis 9

XRD (single crystal), XRF, detailed principle, operation and applications, compositional surface analysis; XPS, SIMS, contact angles, X-ray analysis, ESCA, limitations and scope of application for various nanomaterials.

UNIT V : Particle size and thermal analyzer

Measurements of size of nanoparticles, DTA, TGA and DSC measurements in characterization of nanostructured materials.

Total:45

TEXT AND REFERENCES :

1. Introduction to Nanotechnology , Frank J. Owens, , Charles P. Poole, Wiley-IEEE, (2003).
2. Encyclopedia of Nanoscience & Nanotechnology, Hari Singh Nalwa, American Scientific Publishers, Published 2004.
3. X-ray diffraction procedures,H. P. Klung and L.E.Alexander, John Wiley& sons.
4. The Powder Method, L.V.Azaroff and M. J. Buerger, McGrawHill, 1958.
5. Introduction to Solid,L.V. Azaroff, McGrawHill publishers.
6. Elements of X-ray diffraction , Bernard Dennis,Cullity, Addison-Wesley, Published 1978.
7. Differential Thermal Analysis, R.C.Mackenzie, Academic Press, London, 1972.
8. Thermal Methods of Analysis ,W.W.Wendlandt, Interscience-Wiley, New York (1964).
9. Synthesis, Functionalization and Surface treatment of Nanoparticles : Marie-Isabelle Baraton, American Scientific Publishers, Published 2003.
10. Nanomaterial Systems Properties and Application, S. Edelstein,, Robert C. Cammarata, CRC Press, Published 1998.

1. Simulation Programming for Nano structures and Nano designs using simulation softwares.

YNT208 NANOTECHNOLOGY LAB - II

0 0 3 3

1. Electrophoresis – DNA separation and patterning.
2. UV- VIS – IR s spectra photometer.
3. TEM, SEM and AFM – Demonstration X –Ray.
4. TiO₂, Al₂O₃, SnO₂, CNT and ZnO films, Quantum Dots and its sensing properties.

Total:45

UNIT I: Materials Structure

Crystal Structures, Face-Centered Cubic Nanoparticles, Tetrahedrally Bonded Semiconductor Structures, Lattice Vibrations, Size Dependence of properties
Free electron theory of solids, Band theory of solids, The Bloch theorem, the Kronig-Penny model, motion of electrons in three dimensional lattice, Brillouin zones, The Wigner-Seitz approximation
Energy Bands - Insulators, semiconductors, and Conductors. Reciprocal Space, Energy Bands and Gaps of Semiconductors, Effective Masses, Fermi Surfaces

UNIT II: Properties of Individual Nanoparticles

Localized Particle, Donors, Acceptors, and Deep Traps, Mobility, Excitons. Metal Nanoclusters- Magic Numbers, Theoretical Modeling of Nanoparticles
Geometric Structure, Electronic Structure, Reactivity, Fluctuations, Magnetic Clusters, Semiconducting Nanoparticles- Optical Properties, Photofragmentation and Coulombic Explosion

UNIT III : Bulk Nanostructured Materials

Bulk to Nanotransition, Solid Disordered Nanostructures, Failure Mechanisms of conventional Grain-Sized Materials, Mechanical Properties, Nanostructured Multilayers, Electrical Properties, Others Properties, Metal Nanocluster Composite Glasses, Porous Silicon. Nanostructured Crystals- Natural Nanocrystals, Computational Prediction of Cluster Lattices, Arrays of Nanoparticles in Zeolites, Crystals of Metal Nanoparticles Nanoparticle Lattices in Colloidal Suspensions and Photonic Crystals

UNIT IV: Nanostructured ferromagnetism

Diamagnetism – para magnetism, paramagnetic relaxation - nuclear magnetic resonance – magnetic moments – Bloch equation. Basic of Ferromagnetism-ferro magnetic resonance and relaxation, Effect of Bulk Nanostructuring of Magnetic Properties, Dynamics of Nanomagnets, Nanopore Containment of Magnetic Particles, Nanocarbon Ferromagnets, Giant and Colossal Magnetoresistance and Ferrofluids

UNIT V: Quantum Nanostructures

Size Effects, Conduction Electrons and Dimensionality, Fermi Gas and Density of States, Potential Wells, Partial Confinement, Properties Dependent on Density of States Excitons, Single-Electron Tunneling, Applications - Infrared Detectors, Quantum Dot Lasers and Superconductivity, Optical properties of semiconductors – band edge energy.

UNIT I : Introduction of MEMS and NEMS**9**

Overview, working of sensors and microactuation scanning laws, materials for MEMS, active substrate materials as MEMS and NEMS materials, considerations for microfabrication, bulk micromanufacturing, surface micromachining.

UNIT II: Epitaxy growth**9**

Crystal growth by CVD, PCVD, MBE and MOCVD.

UNIT III : Processing technologies**9**

Cleaning of wafers, cleaning conditions, cleaning complexes, oxidation and nitrite films, diffusion of impurities, photolithography,(optical, X-ray, contact and proximity, electron beam lithography), LIGA and steriolithography, sol-gel techniques for growth of thin films, metallization for contacts using thermal, electron beam deposition and sputtering techniques.

UNIT IV: Micromachining**9**

Bulk, surface, etch stop, porous, Silicon, DRIE, shape memory alloys, bonding of nanostructures and related theories.

UNIT V : Characterization**9**

Photoluminescence, infrared techniques and electrical and magnetic parameters.

Total:45**TEXT AND REFERENCES:**

1. VLSI Fabrication Principles,SK Gandhi, John Wiley & Sons, New York, 1983.
2. Semiconductor technologies, Junichi Nishizawa, North-Holland, Published 1982

UNIT I: Introduction to Microfluids**9**

Continuum Governing equation, boundry conditions, Cate and Poiseuille flow, thin film equations, flow in nanotubes.

UNIT II: Transport Phenomena**9**

Ficks law, hydrodynamic equations, Navier-stokes equation, Boltzmann transport equation, Kubo formulae, application to confined fluid at nanoscale.

UNIT III: Surface tension**9**

Static and dynamic contact angle, surface energies, thermocapillary and electrocapillary flows.

UNIT IV: Electrohydrodynamics**9**

Poisson Boltzmann double layers, electrosmosis, electrophoresis in liquids.

UNIT V: Microfluidics Devices**9**

Microarray, chips as well componentry, pumps, mixers, valves, Lithography, etching, photopolymerization, multilayer soft lithography.

Total : 45**TEXT AND REFERENCES:**

1. Physical Chemistry of Surfaces : Arthur W. Admson and Alice P. Gast, Wiley, Published 1997.
2. Fundamentals of Microfabrication; the Scientific miniaturization : Mare J. Madou, CRC Press, Published 2002.
3. Colloidal Dispersion by W.B. Russel, D.A.Saville, W.R.Schwalter, Cambridge University Press.
4. Statistical Mechanics : Donald Allan, McQuarrie, Harper & Row, Published 1976.

YNT105D NANO BIOTECHNOLOGY 3 0 0 3

UNIT I : Biophysics 9

Bioelectromagnetism, Bioenergetics.

UNIT II : Bioinformatics 9

Use of database in biology, Sequence data bases EMBL, NBAF, Protein structural databank.

UNIT III: 9

Sequence analysis of proteins and nucleic acids. Structure prediction, simple molecular modeling.

UNIT IV : Applications 9

Nanotherapeutics, Molecular diagnostics, Tissues engineering, Nanopump and biological harvests.

UNIT V : 9

Nanorobotic cells, Molecular motors, Nanomembrances, Organic Molecules based computers, Bionanodevices (sensors & actuators).

Total:45

TEXT & REFERENCES:

1. Biophysics, Vasantha Pattabhi, Gautham, N. Springer Published 2002.
2. Nanostructures and Nanomaterials, Guozhong Cao, Imperial College Press, Published 2004.
3. Introduction to Bioinformatics. Lesk L.A, Oxford University Press. 2003.

YNT106A MOLECULAR NANO-ELECTRONICS

3 0 0 3

UNIT I :Basic of Molecular Electronics

9

Silicon based electrical devices and logic circuits, CMOS device parameters and scaling, memory devices.

UNIT II :Molecular Electronic computing Architectures

9

Computer architectures based on molecular electronics, characterization of switches and complex molecular devices, polyphenylene based molecular rectifying diode switches : design and theoretical characterization, novel designs for diode based molecular electronic digital circuits.

UNIT III :Nanoelectronic & nanocomputer Architectures and Nanotechnology

9

Introduction to nanoelectronic and nanocomputer, Quantum – DOT Cellular Automate (QCA), Single electron circuits, molecular circuits Nanocomputer architecture and architectronics, Information theory entropy analysis and optimization.

UNIT IV :Spintronics : (Spin based Electronics)

9

Spin Transfer electronics is electrical systems, potential spinotronics devices, quantum computation and spintronics, Issues in spin electronics.

UNIT V :QWIP (Quantum Well Infrared Photo detector)

9

Introduction, QWIP Focal plane Array Technology; Voltage – tunable QWIPS, Quantum grid infrared photo detectors.

Total:45

TEXT & REFERENCES:

1. The Physics of Quantum well Infrared Photo detectors : Kyung K. Choi, World Scientific, Published 1997.
2. Detection of optical and Infrared Radiation, RH Kingston and DL MacAdam, Springer,

UNIT I : Theoretical Basics of Carbon Nanobute **9**

Linear elastic properties, nonlinear elasticity and shell model, atomic relaxation and failure mechanism, kinetic theory of strengths Coalescence of nanotubes as a reversed failure, persistence length, coils and random fuzz balls of CNTS.

UNIT II : Preparation of Carbon Nano-Tubes **9**

Nanotube growth, material developments CVD and other methods of preparation of CNT like Simulation methods.

UNIT III : Properties of Carbon Nanotubes **9**

Structure and properties of CMT, Computational modeling and simulation Electrical, Optical, Mechanical, Vibrational properties etc.

UNIT IV : Applications of Carbon Nanotubes **9**

Mechanical Properties of nanotubes, Field mission, Fuel Cells, Display devices, An introduction to ceramic based sensors (TiO_2 , Al_2O_3 , MgO) and their applications

UNIT V : Dendrimers – (An Enabling Synthetic Science to Controlled Organic Nanostructures) **9**

The Dendritic State, Unique Dendrimer Properties, Dendrimers as Nanopharmaceuticals and Nanomedical Devices, Dendrimers as Reactive Units for the Synthesis of More Complex Nanoscale Architectures

Total:45

TEXT & REFERENCES :

1. Nanobiotechnology; ed C M Niemeyer, C A Mirkin, Wiley-VCH, Published 2006.
2. Nanocomposite Science and Technology, Pulickel M. Ajayan,, Linda S. Schadler, Paul V. Braun, Wiley-VCH, Published 2006.

UNIT I Biosensors – General Principles**9**

Definition, General characteristics. Physical bio detection – Electrochemical detection, Thermometric detection, Piezoelectric detection, Photometric detection. Chemical bio detection – transformation reactions. Coupling reactions. Instrumentation. Principles of biosensors.

UNIT II Construction of Biosensors**9**

Choice of bio receptors, Immuno receptors, Chemo receptors. Choice of transducers. Immobilization of bioreceptors, Immobilization of micro organisms, Immobilization of immuno agents, Immobilization of tissue organelles and chemoreceptors.

UNIT III Enzyme sensors**9**

Principles of Operation, Theoretical aspects, Stability of enzyme sensors, Study of enzymatic inhibition, Practical aspects, Potentiometric enzyme electrodes, Amperometric enzyme electrodes, Semiconductor enzyme sensors, Optical enzyme sensors, Thermal enzyme sensors. Microbial Sensors.

Immunological sensors**9**

Antigen – Antibody coupling – Electrochemical sensors , Optical sensors-Optical fibers and Surface plasmon resonance, Semiconductor sensors, Piezo electric sensors, Enzymatic labeling – Electro chemical, Optical, Thermal methods. Other biosensors and Applications

UNIT IV Data Acquisition**9**

Data and information capture in health care management and clinical delivery systems – multi modal data- epidemiology and etiology data-data quality-importance of data organization and retrieval of healthcare and clinical database systems-Implementation for medical systems.

UNIT V Biomarkers**9**

Biomarkers, Difference between Biomarkers and Surrogate end points, Visualization of Biomarkers, Example of Biomarkers in everyday medical imaging. Analysis Techniques. Advantage of Biomarkers in evaluation of new drugs and devices. Pitfalls of using Biomarkers as clinical trial endpoints.

Total:45

REFERENCES:

1. **Biosensors** (Sensor Physics and Technology) by Tran Minh Canh,
Published by Chapman & Hall ,Springer.
2. Principles of Applied Biomedical Instrumentation – L.A Geddes , L.E.Baker.
3. T.Dentsh D.Carson & Carson & E.Ludwig : Dealing with Medical Knowledge-
Computers in clinical decision making. Plenum press,1994.
4. www.biomarkers.org
5. www.lcsciences.com

UNIT I : Nanomanipulation & Assembly : An Introduction**9**

Concept of manipulation in nanostructures and nanoassembly, experimental realization, limitation of present day instrumentation, future out look.

UNIT II : Nanomanipulation**9**

Buckling, Transport, and Rolling at the Nanoscale. Instrumentation Systems : The Nanomanipulator and Combined Microscopy Tools, Nanomanipulation for Mechanical Properties.

UNIT III : Nanoparticle Manipulation by Electrostatic Forces**9**

Theoretical Aspects of AC Electro kinetics, Applications of Dielectrophoresis on the Nanoscale, Limitations of Nanoscale Dielectrophoresis

UNIT IV : Biologically Mediated Assembly of Artificial Nanostructures and Microstructures**9**

Bio-Inspired Self-Assembly, The Forces and Interactions of Self-Assembly, Biological Linkers, State of the Art in Bio-Inspired Self-Assembly, Future Directions

UNIT V : Nanostructural Architectures from Molecular Building Blocks**9**

Bonding and Connectivity, Molecular Building Block Approaches.

Total:45**TEXT & REFERENCES :**

1. Handbook of Nanostructured Materials and Nanotechnology : Hari Singh Nalwa
Academic press. Published 2000.
2. Scanning Probe Microscopy & Spectroscopy : Theory, Techniques & Applications :
3. Dawn A Bonnell, Wiley-VCH, Published 2001.
4. Micro/Nanotechnology and its Applications : B. Bhushan, Kluwer publishers.
5. Robot Hands & Mechanics of Manipulation : Matthew T. Mason, J. Kenneth Salisbury, MIT Press, Published 1985

YNT205B SELF-ASSEMBLING NANOSTRUCTURED MOLECULAR MATERIAL AND DEVICES

3 0 0 3

UNIT I : Self-assembly and nanofabrication

9

Self organization of nanosized building blocks to form 2D / 3D structures. Biological molecules in self-assembly and organization, DNA directed self-assembly.

UNIT II :Self-assembled molecular structures

9

Vesicles : Types, formation and applications; Liposomes: Formation, applications, Dendrimers: Unique properties, applications and use in formation of nanostructure.

UNIT III :Supramolecular Complexes

9

Application as molecular devices, detectors, catalysts; Natural supramolecular structures / complexes, Formation of artificie Supramolecular complexes.

UNIT IV :Self assembled Monolayers

9

Fabrication and applications of SAMs and Langmuir Blodgett films using organic molecules.

UNIT V :Membrane and Mesoporous materials

9

Synthesis of mesoporous materials; applications in nanotechnology.

Total:45

TEXT & REFERENCES:

1. Nanoparticles (Building Blocks for Nanotechnology), Vincent M. Rotello, Springer, Published 2004.
2. Nanostructured Materials (Processing, Properties and Applications); Carl C Koch, William Andrew Inc.,Published 2006.
3. Nanoparticles;ed Gunter Schmid, Published 2006,Wiley-VCH
4. Nanobiotechnology; ed C M Niemeyer, C A Mirkin, Wiley-VCH, Published 2006
5. Handbook of Nanotechnology; Bhushan, Springer,2006.
6. Handbook of Applied Surface and Colloid chemistry, vol 1& 2, Krister Holmberg,John wiley,2001.

YNT205C SEMICONDUCTOR NANOCLUSTERS AND NANOPARTICLES

3 0 0 3

UNIT I : Semiconductor Nanoparticles

9

Synthesis and properties of nanocrystals and nanoclusters, Super lattices of Semiconductor nanoparticles.

UNIT II : Nanostructured semiconductor films

9

Synthesis, characterization and applications, DLC semiconductor film preparation, Large & different band gap semiconductor materials

UNIT III : Diamond like carbon semiconductor

9

Method of preparation, properties and possible industrial applications.

UNIT IV : Different band gap semiconductors

9

Preparation of different semiconductors, measurement of band gap by UV-VIS and electrical and optical properties.

UNIT V : Langmuir-Blodgett film

9

Preparation of films, characterization by instrumental methods.

TOTAL : 45

Text & References :

1

Electronic devices from diamond-like carbon in Semiconductor Science and Technology (Review Article) Volume 18 Page S81-S85 – W I Milne
Diamond-like amorphous carbon (Review Article) Journal: Mat. Sci.Eng Volume: 37 Page: 129-281 – J Robertson
Applications of diamond films and related materials Y Tzeng, M Yoshikawa, M Murakawa, A Feldman
Solid State Physics, C Kittel, 5th edition, Wiley.
Solid State Physics, Neil W. Ashcroft, N. David Mermin Holt, Published 1976, Rinehart and Winston.
Long Wavelength Infrared Detectors (Optoelectronic Properties of Semiconductors and Superlattices) – Manijeh Razeghi, CRC press, 1996.
Semiconductor Quantum Wells and Superlattices for Long, Wavelength Infrared Detectors – M O Manasreh, Artech House, Published 1993.
Light scattering in semiconductor structures and superlattices (Resonant Raman scattering in GaAs/GaAlAs multiquantum wells under magnetic fields). J M Calleja, F Meseguer, F Calle, C Lopez, L Vina, and C Tejedor. Editor: D J Lockwood and J F Young, Springer 1991

**YNT205D NANOPARTICLES, MICRO – ORGANISMS, AND BIOMATERIAL
HYBRID SYSTEMS**

3 0 0 3

**UNIT I : Microorganisms for synthesis of nanomaterials and toxicity
detection**

9

Natural and artificial synthesis of nanoparticles in microorganisms; Use of microorganisms for nanostructure formation.
Testing of environmental toxic effect of nanoparticles using microorganisms;

UNIT II : Nanoparticles for bioanalytical applications

9

Nanoparticles as molecular labels; biological labeling using quantum dots.

UNIT III : Nanoparticle-biomaterial hybrid systems for bioelectronics devices

9

Bioelectronic systems based on nanoparticle-enzyme hybrids; nanoparticle based bioelectronic biorecognition events.

UNIT IV : Biomaterial based metallic nanowires, networks and circuitry

9

DNA as functional template for nanocircuitry; Protein based nanocircuitry;

UNIT V : DNA nanostructures for mechanics and computing

9

DNA based computation; DNA based nanomechanical devices.

Total:45

TEXT & REFERENCES :

1. Nanobiotechnology; ed C M Niemeyer, C A Mirkin, Wiley-VCH, Published 2006.
2. Nanocomposite Science and Technology, Pulickel M. Ajayan,, Linda S. Schadler, Paul V. Braun, Wiley-VCH, Published 2006.

UNIT I: Need for New Perspectives on Medicine

Basic Concepts of Nanomedical Systems, Overview of Basic Nanomedical Systems Design, Designing "Theragnostic" Systems

UNIT II: Cell Targeting

Rare-event targeting of cells in-vitro and in-vivo, Normal & facilitated cell entry mechanisms

Magnetic nanoparticle for drug targeting, Virus like nanoparticle targeting, Thermoresponsive polymer assemblies for cell targeting

UNIT III: Technologies for measuring nanomedical systems

Measurements on/within cells, Atomic Force Microscopy (AFM) for Nanomedical Systems (cells and nanoparticles), Introduction to X-ray Photoelectron Spectroscopy and the Examples of Biologically-Relevant Applications, Ultraviolet & Visible spectrophotometry, Fluorescence and Phosphorescence Spectrophotometry, Chemical analysis of surfaces: Ion scattering Spectroscopy (ISS); Secondary Ion Mass spectroscopy (SIMS); Auger Emission Spectroscopy (AES), Electron Spectroscopy for chemical analysis (ESCA).

UNIT IV: Nanomaterials for core design

Fabrication of biomolecule conjugated nanoparticles, Assessing Zeta Potentials, Challenges of proper drug dosing with nanodelivery systems, Nanodelivery of therapeutic genes & molecular biosensor feedback control systems, Assessing drug efficacy at the single cell level, Assessing nanotoxicity at the single cell level

UNIT V: Designing of nano drug delivery systems

Nanodelivery system for in-vivo use, In vivo model systems to study nanomedical approaches to cancer detection and intervention, GMP and issues of quality control manufacture of nanodelivery systems BME 695N FDA and EPA Regulatory Issues.

YNT206B APPLICATIONS OF NANOMATERIALS IN ENERGY CONVERSION PROCESS

3 0 0 3

UNIT I: Photovoltaics

UNIT II: Inorganic semiconductors

Organic semiconducting (macro)molecules; orbitals and conjugation; Excitations: excitons and polarons; Exciton spin: singlets and triplets; Synopsis electronic and optical processes; Optical properties: a few examples EG (Energy Gap) vs. molecular weight Electron-phonon coupling: vibrational structure and thermochromism, Förster transfer and Site selective spectroscopy; Summary of optical properties

UNIT III: Polymer-based light-emitting diodes

Fundamental processes; Charge injection; Charge transport; Exciton formation Mutual capture Exciton characteristics (binding energy, spin-multiplicity, capture cross-section); Exciton decay, Radiative and non-radiative decay; Exciton lifetime Efficiency; Characterisation of PLEDs; Relevant performance parameters; Characterising metal-semiconductor contacts: electroabsorption measurements as a non-invasive tool for the study of the energy level line up in finished devices; Practical implementations; Anodes; Cathodes; Active materials; Singlet emitters; Triplet emitters; enhanced spin-orbit coupling via doping with rare-earth ligands; Blends: trying to achieve the best of all worlds; Prototypical materials for red, green and blue emission (singlet emitters); Fabrication technology: the advantage of solution processability; Spin-coating Ink-jet printing (IJP); Screen-printing and other examples; State of the art devices and future prospects

UNIT IV : Organic Solar Cells and Quantum dots in energy conversion

Polymer-based photovoltaic diodes (PVDs) - Fundamental process; Exciton absorption; Exciton dissociation; Charge collection; Characterisation of PVDs; Relevant performance parameters; Examples of polymer-based PVDs; Polymer-polymer heterojunctions; Enhanced dissociation at type II heterojunctions; Preparation methods: polymer blends and spontaneous phase separation; C60-polymer structures; Heterojunctions with nanocrystals, nanorods, etc; State of the art devices and future prospects

UNIT V : Nanomaterials in fuel Cell Applications

UNIT I: Optical Signal Processing

Laser and Optical fibres, Photo emitters/Photo converters, Photomultipliers, Photodetector/Transducer, Luminescent Devices and Optical Instrumentation

UNIT II: Photomaterials

Photochemistry, Polymer, Conducting Polymers, LEP

UNIT III : Optical Coatings

Photoresist/Antireflection Coating, Transparent Conductors

UNIT IV : Molecular Photonics

UNIT V : Optical Computing

Holography, Optical memories, Optical Chips

UNIT I : Historical Retrospection : From first Industrial Revolution to the Nanorevolution :

9

Invention of wheel (3500BC) to James Watt Engine (1765) : First Industrial Revolution; Industrial Automation : Second Industrial Revolution; Semiconductor Industry : Third Revolution (Digital revolution & evolution of computer age), emergence of Information and communication technologies and biotechnology, Richard Feynman (1959) and development of nanotechnology.

UNIT II : Nanotechnology & Sustainable Development :

9

Economic development involving biodiversity and utilization of nanomaterials ; safe drinking water, Improving food security, Health diagnosis, monitoring and screening, control our environmental pollution, Energy storage, Production & conversion and Global Partnership.

UNIT III : Nanoethics : A Deontological code for nano-community

9

Formalisation of deontological code to bridge the gap between science & ethics ; protection of individual privacy and maintenance of dignity.

UNIT IV : Implications of Nanotechnology on society

9

Impact of nanotechnology on society, fusion of natural and human sciences reliability, safety risks : assessment and management, public & private investments, Intellectual property right (IPR); nanorules & regulations.

UNIT V : Future outlook in Nanotechnology :

9

Unexplored biodiversity for bionanotechnology ; bionanodevices, emergence of global nanoworld.

Total:45

TEXT & REFERENCES:

1. Societal Implications of Nanoscience and Nanotechnology : M.Roco and W Bainbridge, Kluwer, Netherlands (2001).
2. Social & Economics challenges of Nanotechnology, Economic and Social Research Council, Swindon UK (2003).
3. Nanotechnology : Small Matter, Many Unknowns www.swissre.com .