Bharati Vidyapeeth Deemed University

College of Engineering, Pune- 411043

The Syllabus of the Curriculum: 2015 Course

M. TECH. (NANOTECHNOLOGY):
SEMESTER- I to IV

Bharati Vidyapeeth University

College of Engineering, Pune

Department of Mechanical Engineering

Vision of the Bharati Vidyapeeth (Deemed to be University) College of Engineering is:

To be a World Class Institute for Social Transformation through Dynamic Education

Missions of the Bharati Vidyapeeth (Deemed to be University) College of Engineering are:

- *To provide quality technical education with advanced equipment, qualified faculty members, infrastructure to meet needs of profession & society.*
- *To provide an environment conducive to innovation, creativity, research and entrepreneurial leadership.*
- *To practice and promote professional ethics, transparency and accountability for social community, economic & environmental conditions.*

Goals of the Bharati Vidyapeeth (Deemed to be) University College of Engineering are:

- *Recruiting experienced faculty.*
- *Organizing faculty development programs.*
- *Identifying socio-economically relevant areas & emerging technologies.*
- *Constant review &up gradation of curricula.*
- *Up gradation of laboratories, library & communication facilities.*
- *Collaboration with industry and research & development organizations.*
- *Sharing of knowledge, infra-structure and resources.*
- *Training, extension, testing and consultancy services.*
- *Promoting interdisciplinary research.*

Vision of the Mechanical Engineering Department is:

To develop, high quality Mechanical Engineers through dynamic education to meet social and global challenges.

Mission Statements of the Mechanical Engineering Department are:

- *To provide extensive theoretical and practical knowledge to the students with well-equipped laboratories and ICT tools through motivated faculty members.*
- *To inculcate aptitude for research, innovation and entrepreneurial qualities in students.*
- *To acquaint students with ethical, social and professional responsibilities to adapt to the demands of working environment.*

Program Educational Objectives (PEOs) of the B. Tech. Mechanical are:

Graduates will be able,

- *To fulfill need of industry and society with theoretical and practical knowledge.*
- *To engage in research, innovation, lifelong learning and continued professional development.*
- *To fulfill professional ethics and social responsibilities.*

PROGRAM OUTCOMES

Engineering Graduates will be able to:

1. ***Engineering knowledge****: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.*

2. ***Problem analysis****: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.*

3. ***Design/development of solutions****: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.*

4. ***Conduct investigations of complex problems****: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.*

5. ***Modern tool usage****: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.*

6. ***The engineer and society****: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.*

7. ***Environment and sustainability****: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.*

8. ***Ethics****: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.*

9. ***Individual and team work****: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.*

10. ***Communication****: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.*

11. ***Project management and finance****: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.*

12. Life-long learning*: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.*

Statements of Programme Specific Outcomes (PSOs)

PSO1: Apply the knowledge of thermal, design, manufacturing engineering and computational sciences to solve Mechanical Engineering problems.

PSO2: Apply Mechanical Engineering principles for research, innovation and develop entrepreneurial skills.

PSO3: Apply concepts of mechanical engineering to asses' societal, environmental, health and safety issues with professional ethics.

Rules for Conducting Tests

Mode of the test

- In each semester for each subject two tests shall be conducted. The schedule for the same willbe declared at the commencement of academic year in the academic calendar.
- Each test shall carry 20 marks.
- University examination pattern has given weightage of 20 marks for the tests.

- To calculate these marks following procedure is followed:

  i) Average marks obtained in two tests shall be considered as provisional marks obtained by the student in the tests.

  ii) If the candidate appears only for one test during the semester, to calculate the marks obtained in the tests it will be considered that the candidate has got 0 (zero) marks in othertest.

  iii) The provisional marks obtained by the candidate in class tests should reflect as proportional to theory marks. In cases of disparity of more than 15% it will be scaled down accordingly; these marks will be final marks obtained by the student. No scaling up is permitted.

  iv) If the candidate is absent for theory examination or fails in theory examination his final marks for tests of that subject will not be declared. After the candidate clears the theory, the provisional marks will be finalized as above.

  - Paper pattern for tests

    i) All questions will be compulsory with weightage as following

    Question 1 - 7 marks

    Question 2 - 7 marks

    Question 3 - 6 Marks

    ii) There will not be any sub-questions.

  - For granting the term it is mandatory to appear for both tests conducted in each semester.
  - Roll nos. allotted to students shall be the examination nos. for the tests.

TEACHING SCHEME	EXAMINATION SCHEME	
Lectures : 04 Hrs/Week	Theory	: 60 Marks
Practical : 02 Hrs/Week	Duration	: 03 Hours
	Unit Test –I	: 20 Marks
	Unit Test –II	: 20 Marks
	TW/Pract./Oral	: 50 Marks
	Theory Credits	04
	Practical Credits	01

Unit-I **(08 Hours)**

Title: Introduction

Scientific Revolutions – Types of nanomachines and nanotechnology-periodic table-Atomic structure molecules and phase Energy -Molecular and Atomic size -surfaces and dimensional space -Top down and bottom up. Misnomers and misconception of Nanotechnology.

Unit-II **(08 Hours)**

Title: Nanomaterial Synthesis Methods

Introduction to Nano scale materials - Synthesis and processing, method of nano structured material preparation – mechanical grinding, wet chemical synthesis – sol-gel processing, gas phase synthesis, gas condensation processing, chemical vapor condensation – nano composite synthesis – processing.

Unit-III **(08Hours)**

Title: NanoStructures

Introduction, length scale of different structures, definition of nanoscience and nanotechnology, fullerenes, CNTs, graphenes and inorganic nanostructures, the evolution of Nanoscience, quantum dots and electronic structure of various nanophase materials. Clusters of metals and semiconductors, rare gas and molecular clusters, nanowires and nanorods, size dependent properties, size dependent absorption, phonons in nanostructures. Quantum dots - Nano wires-Nano tubes 2D and 3D films Nano and mesopores, micelles, bilayers, vesicles, bio-nano machines-biological membranes. Dendritic and supramolecular structures, metal nanocluster composites, glasses. Biological building blocks, bionanopolymers, self-assembly by Nature. Polypeptide nanowire and protein nanoparticles, nucleic acids, DNA helix. Examples of biological nanostructures, proteins, micelles and vesicles, proteins, Amphiphilicity as a driving force in synthesis of biological structures. Multilayers. Bio-nano interface.

Unit-IV **(08 Hours)**

Title: Nanomaterial Properties

Opportunity at the nano scale - Length and time scale in structures -energy landscapes-Inter dynamic aspects of inter molecular forces -Evolution of band structure and Fermi surface.

Unit-V **(08hours)**

Title: Physical Properties Of Nanostructured Materials

Influence of Nano structuring on Mechanical - Optical, electronic, magnetic and chemical properties –gramsize effects on strength of metals optical properties of quantum dots and quantum wires –electronic transport in quantum wires and carbon nano tubes -magnetic behavior of single domain particles and nanostructures-surface chemistry of tailored monolayer -self assembling. Nano Characterization, mechanical characterization, structural characterization

Unit-VI **(08 Hours)**

Title: Applications of Nanotechnology

Industrial applications of nanomaterials, in the areas of electronics, photonics, biology, health and environment, medicine, defence, chemicals, catalysts, textiles, etc. Application of nanotechnology in remediation of pollution, photocatalysis and other nanocatalysts, greenhouse gases, global warming. Monitoring nanoparticles at work place and sensors used for this. Toxicity of nanoparticles, exposure to nanoparticles and CNTs and influence on respiratory systems.

Termwork

At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Books /Text References

1.Mick Wilson, Kamali Kannargare., Geoff Smith, ‒Nano technology: Basic Science and Emerging technologies‖, Overseas Press, 2005.

2 Charles P. Poole, Frank J. Owens, ‒Introduction to Nanotechnology‖, Wiley Interscience, 2003.

3. Mark A. Ratner, Daniel Ratner, ‒Nanotechnology: A gentle introduction to the next Big Idea‖, Prentice Hall P7R:1st Edition, 2002.

4. Nanostructures and Nanomaterials: synthesis, properties and applications, G. Cao and Y. Wang, World Scientific, 2nd edition, 2011

5. Encyclopedia of nanoscience and nanotechnology, Edited by H.S. Nalwa, American Scientific Publishers, 2007

6. Nanotechnology book by Prof. (Ms) Sulabha Kulkarni

REFERENCES

1. Nanoelectronics and nanosystems: from transistors to molecular and quantum devices, K. Goser, P. Glosekotter and J. Dienstuhl, Springer 2005
2. Handbook of Thin Film Materials, volume 5, edited by H.S Nalwa, American Scientific Publishers, 2002
3. Nanoelectronics- principles and devices, M. Dragoman and D. Dragoman, Artech House publishers, 2005
4. Overview of Nanoelectronic Devices, D. Goldhaber Gordon, Proceedings of IEEE, volume 85, 1997
5. Nanoelectronics and Information Technology, W. Rainer, Wiley, 2003
6. Nanosystems, K.E. Drexler, Wiley, 1992
7. Science of fullerenes and carbon nanotubes, M.S. Dresselhaus and G. Dresselhaus, Academic press, 1996

Syllabus for Unit Test

Unit Test 1- Units I ,II and III
Unit Test 2- Units IV,V and VI

NANO PHYSICS

TEACHING SCHEME
Lectures : 04 Hrs/Week

EXAMINATION SCHEME

Theory	: 60 Marks
Duration	: 03 Hours
Unit Test –I	: 20 Marks
Unit Test –II	: 20 Marks
Theory Credits	04

Unit-I **(08 Hours)**

Atomic and Molecular Physics:

Rutherford atom model, Electron orbits, Bohr atom, Energy levels and spectra, Atomic excitation and atomic spectra, Rotational & Vibrational energy levels, Rotational and Vibrational spectra. Electronic spectra of molecules. Bohr and Sommerfield atom models - Vector atom model - Pauli's exclusion principle - various quantum numbers - angular momentum and magnetic moment - coupling schemes - LS and JJ coupling - Bohr magneton, Hund's rule, Stern and Gerlach experiment, Zeeman Effect and stark Effect. Molecular bonding in homo and hetero nuclear molecules, polyatomic molecules, vibration and rotational levels, vibrations and Group frequencies.

Unit-II **(08 Hours)**

Quantum Mechanics:

Wave-particle duality, Schrodinger equation and expectation values, Uncertainty principle. Solutions of the one-dimensional Schrodinger equation for free particle, particle in a box, particle in a finite well. Reflection and transmission by a potential step and by a rectangular barrier. Theory of radiation, transition probability for absorption and emission, forbidden transitions, decays, lifetime concepts.Solution of Time independent Schrödinger equation at higher dimensions. Particle in a three dimensional box, linear harmonic oscillator and its solution, density of states, free electron theory of metals. The angular momentum problem. The spin half problem and properties of Pauli spin matrices.

Unit-III **(08Hours)**

Solid State Physics:

Amorphous, crystalline, crystals, polycrystals, symmetry. Unit Cells, Crystal Structures (Bravais Lattices), Crystallographic Directions, Crystallographic Planes, Miller Indices, Bragg's Law, X-ray Diffraction. Imperfections of crystal structure: point defects, Grain boundaries, phase boundaries, Dislocations: Screw, Edge and Mixed Dislocations. Free electron theory, Bloch theorem. Motion of electrons in solids, effective mass of electron and hole, reduced, periodic and extended zone scheme, Fermi surfaces, Direct and indirect band gaps in semiconductors, temperature dependence.

Electronic, ionic and orientational polarizabilities, Clausis-Mossotti relation, static and frequency dependence of dielectric constant, Kramers-Kronig relation. Mean field theory, Heisenberg interaction, magnons, origin of domains in magnetic materials.

Unit-IV **(08 Hours)**

Electronics:

Semi conducting materials, p-n junction, space charge and electric field distribution at junctions, forward & reverse biased condition, minority & majority carrier currents, Zener and avalanche break downs, Schottky barrier, Shockley diode & silicon control rectifier, Zener diodes, tunnel diodes, photo diodes. Operational amplifier and Applications– Ideal op-amp, equivalent circuit of op-amp, open loop op-amp configurations – inverting, non-inverting and differential amplifiers, lock-in-amplifier. Active filters – types, first and second order active low and high pass filter. Oscillators – basic principles, types- phase shift oscillator, Wien bridge oscillator, triangular wave generator.

Unit-V **(08Hours)**

Laser Technology:

Basic principles of lasers, properties of laser beams, population inversion in three and four level lasers, resonance frequencies, modifications of the laser output, single mode operation, Q-switching. Laser materials and types of lasers, solid state lasers, characteristics of dye lasers, semiconductor lasers. Laser applications.

Unit-VI **(08 Hours)**

Electrodynamics:

Coulomb's law, Gauss's law, Electrostatic Potential Energy. Biot-Sevart law and Ampere Laws, faraday's law, Maxwell's Equations, Poynting Theorem, Conservation Laws.

Termwork

- At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Books /Text References

1. Herzberg (D. van Nostrand Co., Inc)
2. Berkley Series, Vol. II (Tata McGraw Hill)
3. Modern Quantum Mechanics, J. J. sakurai (Addison Wiley)
4. Quantum Mechanics, L. I. Schiff (McGraw Hill)
5. Quantum Physics, Robert Eisberg and Robert Resnick
6. Classical Electrodynamics, J. D. Jackson (John Wiley)
7. Introduction to Electrodynamics, D. Griffiths
8. Electricity and Magnetism, Reiz, Millford, Christy
9. Introduction to Solids State Physics, C. Kittel (Wiley Estern Ltd.)
10. Elementary Solid State Physics, M. Ali Omar (Addison Wesely)
11. The Art of Electronics, P. Horowitz and W. Hill (Cambridge University Press)

12. Electronic Principle, A. P. Malvino (McGrw Hill)
13. Principles of Quantum Mechanics 2nd ed. - R. Shankar
14. Thermodynamics and Statistical Mechanics - A N Tikhonov, Peter T Landberg, Peter Theodore Landsberg
15. Thermodynamics and Statistical Mechanics by John M. Seddon , J. D. Gale
16. Statistical Physics by K. Huang
17. Statistical Mechanics-Landau &Lifshitz
18. Statistical Mechanics – Sonntag.
19. Statistical Mechanics – Mc Le Leland

Syllabus for Unit Test

Unit Test 1- Units I ,II and III

Unit Test 2- Units IV,V and VI

NANO CHEMISTRY

TEACHING SCHEME
Lectures : 04 Hrs/Week

EXAMINATION SCHEME

Theory	: 60 Marks
Duration	: 03 Hours
Unit Test –I	: 20 Marks
Unit Test –II	: 20 Marks
Theory Credits	04

Unit-I **(08 Hours)**

Title:

Atomic Bonding in solids, Types of bond: Metallic, Ionic, Covalent and vanderwaals bond; Hybridisation; H- bonding Molecular orbital theory for simple molecules such as diatomic molecule etc. Chemical bonding & theories (e.g. Valence band & Molecular Orbital), atomic structure– energy – molecular and atomic size and their properties, Ionic bond, covalent bond, coordination bond,

Unit-II **(08 Hours)**

Title: Types of Material

Metals, Semiconductors, Composite materials, Ceramics, Alloys, Polymers, Their Failure Mechnisms, Properties and Application Areas, Solid state chemistry, Chemistry of surfactants, Polymer chemistry, metal complexes, Inorganic Chemistry, Alkoxide and sol-gel Chemistry, Organometallic chemistry, and their fundamentals for synthesis of oxides & other inorganic Nano composites.

Unit-III **(08Hours)**

Title: Overview to Thermodynamics

The first and second laws of thermodynamics. Thermodynamic, functions, heat capacity, enthalpy, entropy. Phase equilibrium in one component system, real gases, the interactions between gases. Ehrenfest classification of phase transition,the physical liquid surface; surface tension, curved surfaces, capillary action. Theory of Solution and related topics: Liquid mixtures: free energy as a function of composition, ideal solutions and excess functions.

Unit-IV **(08 Hours)**

Title: Chemical Equilibrium

Equilibrium Electrochemistry; electrochemical cells, Methods for calculation of thermodynamic equilibrium. Electrochemical processes, Inorganic complexes, Ionic Equilibria and spectroscopy (UV, IR, Raman),Atomic structure and properties, Oragnometallic chemistry, Thermodynamics of solids,.

Unit-V **(08Hours)**

Title: Diffusion Kinetics

Diffusion-Fick's Law, mechanisms of diffusion; generation of point defects; self-diffusion; the influence of the pressure and pressure gradient; Kirkendall effect; fast diffusion; influence of isotropic state; experimental methods of investigation of diffusion, Chemical kinetics, Chemistry of surfactants, Basic polymer chemistry, Solid state chemistry, Reactivity of solids, Qauntum chemistry

Unit-VI **(08 Hours)**

Title: Reaction Kinetics and Photochemstry

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

Termwork

- At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Books /Text References

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

Syllabus for Unit Test

Unit Test 1- Units I ,II and III
Unit Test 2- Units IV,V and VI

NANO BIOLOGY

TEACHING SCHEME
Lectures : 04 Hrs/Week
Practical : 02 Hrs/Week

EXAMINATION SCHEME

Theory	: 60 Marks
Duration	: 03 Hours
Unit Test –I	: 20 Marks
Unit Test –II	: 20 Marks
TW/Pract./Oral	: 50 Marks
Theory Credits	: 04
Practical Credits	: 01

Unit-I **(08 Hours)**

The Cell: the basic unit of life, Molecular components (DNA, protein, lipids, carbohydrates), Expression of genetic information (Transcription, translation), Tyes of cells: plants, animals, bacteria, viruses and fungi, DNA: Structure, components, physical and chemical properties,

Unit-II **(08 Hours)**

Amino acids and proteins: structure and reactions of amino acids (hydrophilic and hydrophobic), structure of proteins (primary, secondary, tertiary and quaternary), Enzyme chemistry : kinetics of enzyme catalysis,

Unit-III **(08Hours)**

Lipids and carbohydrates: Structure and types of lipids, biological membranes, structure and types of carbohydrates, Basic immunology: Adaptive and innate immunity, cells of immune system, Antigens and antibodies structure and functions

Unit-IV **(08 Hours)**

Cytoskeleton: microtubules, intermediate filaments and microfilaments; cell motility Protein motors: ATP synthase F1 motor, Bacterial Flagellar motor, Proton motive forces, ion channels, chimeric kinesin and myosin motors, Cell signaling, G-protein transmembrane receptors, DNA nanostructures for mechanics and computing, DNA-Protein nanostructures, Biomimetic fabrication of DNA-based metallic nanowires, conjugates and networks.

Unit-V **(08Hours)**

Biological methods of synthesis: Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; S-layer proteins, Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis

Unit-VI **(08 Hours)**

Nano-biotechnology: Interaction between bimolecules and naoparticle surface, Different types of inorganic materials used for the synthesis of hybrid nano-bio assemblies, Nanosensors,

Nanomedicine: Nanotechnology in Diagnostics applications, materials used in Diagnostics and Therapeutic, Environmental and Agricultural Applications of nanotechnology.

Termwork

At least Eight Assignment based on above syllabus

Practicals (Any Five):

1. Microscopic observation of bacterial, plant, fungi and animal cells
2. Temporary preparation of cell / tissues
3. Demonstration of Cytotoxicity/cell viability- Tryphan blue dye exclusion
4. Absorbance spectra of biomolecules (DNA, proteins)
5. Immunodiffusion techniques
6. Isolation and purification of genomic DNA- 2
7. Isolation and purification of plasmid DNA -2
8. Estimation and purification of proteins -2
9. Biological Synthesis of nanoparticles (bacteria, fungi and plants)- 4
10. Demonstration of nanoparticles based drug delivery in cell line-3

Oral

Term work and oral will be based on above syllabus.

Books /Text References

1. Alberts, –Molecular Biology of the cell‖ Garland Science.
2. Lodish, –Molecular cell biology‖ FREEMAN
3. Watson, James, T.Baker, S.Bell, A.Gann, M.Levine, And R.Losick.–Molecular Biology of the gene‖, san francisco: Addison-Wesley,
4. Janis Kuby– Immu nolog y‖ W H Freeman,
5. Nelson, D.L., Fox.M.M., ― Lehninger Principles of Biochemistry‖, W.H.Freeman,
6. B.Lewin, –Genes IX‖, International Edition. Sudbury: Jones & Bartlett
7. R. Cantor, P.R.Samuel, –Biophysical Chemistry‖, W.H., Freeman & Co., 1985.
8. Watson, James, T.Baker, S.Bell, A.Gann, M.Levine, and R.Losick. –Molecular Biology of the Gene‖, 5th ed., San Francisco: Addison-Wesley, 2000.
9. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. Molecular Biology of the Cell. 4th ed. New York: Garland Science, 2002.
10. Branden, Carl-Ivar, and John Tooze. Introduction to Protein Structure. 2nd ed. New York: Garland Pub., 1991.
11. Creighton, E, Thomas, –Proteins: Structures and Molecular Properties‖, 2nd Ed. New York: W.H. Freeman, 1992.
12. Bionanotechnology: Lessons from Nature by David S. Goodsell
13. Nanomedicine, Vol. IIA: Biocompatibility by Robert A. Freitas
14. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology - Hari SinghNalwa
15. Nanobiotechnology; ed. C.M.Niemeyer, C.A. Mirkin.
16. Nanocomposite Science & Technology Ajayan, Schadler & Braun
17. BioMEMS (Microsystems) - Gerald A. Urban

18. Introduction to Nanoscale Science and Technology (Nanostructure Science and Technology) Massimiliano Di Ventra
19. Nanosystems: Molecular Machinery, Manufacturing, and Computation - K. Eric Drexler
20. Springer Handbook of Nanotechnology - Bharat Bhushan
21. Nanobiotechnology; ed. C.M.Niemeyer, C.A. Mirkin.
22. Nanofabrication towards biomedical application: Techniques, tools, Application and impact – Ed. Challa S., S. R. Kumar, J. H. Carola.
23. Nanomedicine, Vol. I: Basic Capabilities
24. Nanomedicine, Vol. IIA: Biocompatibility - Robert A. Freitas
25. Dendrimers I, II, III, Ed. F. Vogtle

Syllabus for Unit Test

Unit Test 1- Units I ,II and III
Unit Test 2- Units IV,V and VI

NANO COMPUTING

TEACHING SCHEME	EXAMINATION SCHEME	
Lectures : 04 Hrs/Week	Theory	: 60 Marks
	Duration	: 03 Hours
	Unit Test –I	: 20 Marks
	Unit Test –II	: 20 Marks
	Theory Credits	04

Unit-I **(08 Hours)**

Title: Fundamental Principles Of Numerical Methods

Root finding, interpolation and approximation, numerical integration and differentiation, solution of systems of linear equations, least squares data fitting, eigenvalue problems, numerical methods for ODEs - initial value problems and boundary value problems, Scientific Modeling - Numerical data and Numerical operations -Numerical Algorithms -Numerical Programs - Numerical Software - Approximations in Mathematical Model building- Numerical integration - Differentiation -Variational finite element methods-Rayleigh's method-Ritz method.

Unit-II **(08 Hours)**

Title: Mathematical Modeling

Introduction to mathematical modeling, review of basic calculus - physical simulation - advantages and limitations - Concept of physical domain and computational domain - assumptions and limitations in numerical solutions – Finite element method and Finite difference method.

Unit-III **(08Hours)**

Title: Differential Equations & Applications

Equations of first order, linear differential equations of second order, power series solutions, Laplace transforms, nonlinear differential equations, Fourier series and boundary value problems. Euler method, Runge-Kutta method, boundary values- partial differential equations - separation of variables-wave equation-Laplace equation-nonlinear partial differential equations - Parabolic (Heat/Diffusion) Equation, Derivation, separation of variables, transformation of boundary conditions, Fourier series and transforms.

Unit-IV **(08 Hours)**

Title: Simulation

Basic concepts of simulation- data manipulation, data exchange of the structure, properties and processing of materials- Molecular dynamics simulation, Derivation, D'Alembert principle, vibrating string/beam, finite Fourier transforms, method of characteristics, wave equation in 2D.

Unit-V **(08Hours)**

Title: Monte Carlo Methods

Basics of the Monte Carlo method-Algorithms for Monte Carlo simulation-Applications to systems of classical particles-modified Monte Carlo techniques-percolation system-variation

Monte Carlo method-diffusion Monte Carlo method - Quantum Monte Carlo method, –Finite difference methods - implicit and explicit schemes, truncation error, single step and multi-step schemes. Finite element methods - Galerkin approximation and solution.

Unit-VI **(08 Hours)**

Title: Nanoscale Modeling and Simulations

Introduction to Matlab OR Mathematica (and their open source counterparts-Scilab and Octave); examples from nano-optics and nano-electronics, Molecular dynamics, computing and simulations, Simulations from ab initio to multiscale Modeling, Nanodesign Nano-CAD.

Termwork

- At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Books /Text References

1. S.C. Chapra and R.P.Canale, –Numerical methods for Engineers‖, Tata McGraw Hill, New Delhi, 2002.
2. Erwin Kreyzig, –Advanced Engineering Mathematics‖, John Wiley & Sons, 2004.
3. R.J. Schilling and S.L. Harris, –Applied Numerical Methods for Engineers using MATLAB and C‖, Thomson publishers, New Delhi, 2004..
4 D. Frenkel and B. Smith, –Understanding molecular simulation from algorithm to applications‖, Kluwar Academic Press, 1999.
5 K. Ohno, K. Esfarjani and Y. Kawazoe, –Introduction to Computational Materials Science from ab initio to Monte Carlo Methods‖, Springer-Verlag, 1999.
6. Partial Differential Equations for Scientists and Engineers, S. J. Farlow
7. Partial Differential Equations - Analytical and Numerical Methods, M. S. Gockenbach
8. Linear Partial Differential Equations for Scientists and Engineers, T. Myint-U and L. Debnath
9. An Introduction to Partial Differential Equations with MATLAB, M. P. Coleman

Syllabus for Unit Test

Unit Test 1- Units I ,II and III
Unit Test 2- Units IV,V and VI

NANO FABRICATION AND ADVANCED SYNTHESIS TECHNOLOGY

TEACHING SCHEME	**EXAMINATION SCHEME**	
Lectures : 04 Hrs/Week	Theory	: 60 Marks
Practical : 02 Hrs/Week	Duration	: 03 Hours
	Unit Test –I	: 20 Marks
	Unit Test –II	: 20 Marks
	TW/Pract./Oral	: 50 Marks
	Theory Credits	: 04
	Practical Credits	: 01

Unit-I **(08 Hours)**

Title: Bulk synthesis

Synthesis of bulk nano-structured materials –sol gel processing –Mechanical alloying and mechanical milling- Inert gas condensation technique – Nanopolymers – Bulk and nano composite materials

Unit-II **(08 Hours)**

Title: Chemical Approaches

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

Unit-III **(08Hours)**

Title: Physical Approaches

Vapor deposition and different types of epitaxial growth techniques- pulsed laser deposition, Magnetron sputtering - Micro lithography (photolithography, soft lithography, micromachining, e-beam writing, and scanning probe patterning). .Inert gas condensation, Arc discharge, RFplasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical Vapour Deposition method and Electro deposition.

Unit-IV **(08 Hours)**

Title: Nanoporous Materials

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

Unit-V **(08Hours)**

Title: Application of Nanomaterials

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

Unit-VI **(08 Hours)**

Title: Lithography Techniques

M based nanolithography and nanomanipulation, E beam lithography and SEM based nanolithography and nanomanipulation, Ion beam lithography, oxidation and metallization. Mask and its application. Deep UV lithography, X-ray based lithography.

Termwork

At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Books /Text References

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

Syllabus for Unit Test

Unit Test 1- Units I ,II and III
Unit Test 2- Units IV,V and VI

NANO CHARACTERIZATION

TEACHING SCHEME
Lectures : 04 Hrs/Week
Practical : 02 Hrs/Week

EXAMINATION SCHEME

Theory	: 60 Marks
Duration	: 03 Hours
Unit Test –I	: 20 Marks
Unit Test –II	: 20 Marks
TW/Pract./Oral	: 50 Marks
Theory Credits	04
Practical Credits	01

Unit-I **(08 Hours)**

Title: **MICROSCOPY**

Optical absorption and emission spectroscopy – Basics - AAS – ICP OES – Electron Microscopy: Scanning electron microscopy – Transmission electron microscopy – Scanning tunneling electron microscopy – Image collection in electron microscopes – Environmental transmission electron microscopy – Electron energy loss spectroscopy at the nanometer scale – In-situ nano measurements.- Qualitative approach. Electron Energy Loss Spectroscopy; High Resolution Imaging Techniques- HREM, Atom probe field ion microscopy

Unit-II **(08 Hours)**

Title: THERMAL ANALYSIS METHODS

Principle and Instrumentation of Thermogravimetry; Differential Thermal Analysis and Differential scanning calorimetry-Importance of thermal analysis for nanostructures.

Unit-III **(08Hours)**

Title: SCANNING PROBE MICROSCOPY

Scanning Probe microscopy – Atomic manipulations – Atomic force microscopy – Scanning probe lithography – Optical microscopy – Confocal microscopy – Scanning near field optical microscopy – Secondary ion mass (SIMS) spectrometry – Matrix assisted laser desorption ionization mass spectrometry (MALDIMS).

Unit-IV **(08 Hours)**

Title: SPECTROSCOPIC TECHNIQUES

Introduction to Molecular Spectroscopy and Differences-With Atomic Spectroscopy-Infrared (IR) Spectroscopy and Applications- Microwave Spectroscopy- Raman Spectroscopy and CARS Applications-Electron Spin Resonance Spectroscopy; New Applications of NMR Spectroscopy; Dynamic Nuclear Magnetic Resonance; Double Resonance Technique. Spectroscopy of semiconductors – Excitons – Infrared surface spectroscopy – Raman spectroscopy – Brillouin spectroscopy – Dynamic Light Scattering (DLS) – NMR Spectroscopy – ESR spectroscopy – Mossbauer spectroscopy

Unit-V **(08Hours)**

Title: Nanoindentation Mechanical Characterisation

Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions- models for interpretation of nanoindentation load-displacement curves- Nanoindentation data analysis methods-Hardness testing of thin films and coatings- MD simulation of nanoindentation. Mechanical Characterization – Modulus and load carrying capability of nano region/ compression - microhardness – Fatigue – Abrasion and wear resistance – Super plasticity – Nano indentation – Nano tribology – Nano tribometre – Surface Force apparatus – Quartz crystal microbalance – Friction force microscope.

Unit-VI **(08 Hours)**

Title: Structural Characterization

Neutron and X- ray diffraction – Debye Scherrer formula – Dislocation density – Micro strain macromolecular crystallography using synchrotron radiation – Role for neutron scattering in nano science - Photoluminescence - Thermo luminescence – X-ray absorption Fine Structure (XAFS) – Extended X- ray absorption fine structure (EXAFS) – Electron scattering for chemical Analysis (ESCA). X-ray diffraction (XRD), X-Ray Photoelectron Spectroscopy, X-ray powder diffraction – single crystal diffraction techniques - Determination of accurate lattice parameters – structure analysis - profile analysis - particle size analysis using Scherer formula. X-Ray Characterization of Nanomaterials – EDAX and WDA analysis – EPMA – ZAP corrections.

Termwork

At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Books /Text References

1. B. D.Cullity, ―Elements of X-ray Diffraction‖, 4th Edition, Addison Wiley, 1978.
2. M. H.Loretto, ―Electron Beam Analysis of Materials‖, Chapman and Hall, 1984.
3. R.M.Rose, L.A.Shepard and J.Wulff, ―The Structure and Properties of Materials‖, Wiley Eastern Ltd,
4. B.W.Mott, ―Micro-Indentation Hardness Testing‖, Butterworths, London, 1956.
5. Charles P Poole Jr and Frank J Ownes, ―Introduction to Nanotechnology‖, John Wiley Sons, 2003.
6. Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkar Raguse, ―Nanotechnology:Basic sciences and emerging technologies‖, Overseas Press, 2005.
7. Willard, ―Instrumental Methods of Analysis‖, 2000.
8. Ewing. Etal, ―Instrumental Methods for Chemical Analysis‖, 2000.

Syllabus for Unit Test

Unit Test 1- Units I ,II and III
Unit Test 2- Units IV,V and VI

ENERGY, ENVIRONMENT, SAFETY AND COMMERCIALIZATION FOR NANOTECHNOLOGY

TEACHING SCHEME	EXAMINATION SCHEME	
Lectures : 04 Hrs/Week	Theory	: 60 Marks
	Duration	: 03 Hours
	Unit Test –I	: 20 Marks
	Unit Test –II	: 20 Marks
	Theory Credits	04

Unit-I **(08 Hours)**

Title: Renewable Energy Technology

Energy challenges, development and implementation of renewable energy technologies - nanotechnology enabled renewable energy technologies - Energy transport, conversion and storage, Nano, micro and meso scale phenomena and devices.

Unit-II **(08 Hours)**

Title: Micro Fuel Cell Technology

Micro-fuel cell technologies, integration and performance for micro-fuel cell systems - thin film and microfabrication methods - design methodologies - micro-fuel cell power sources,

Unit-III **(08Hours)**

Title: Microfluidic Systems

Nano-electromechanical systems and novel microfluidic devices - nano engines - driving mechanisms - power generation - microchannel battery - micro heat engine (MHE) fabrication - thermocapillary forces - Thermocapillary pumping (TCP) - piezoelectric membrane.

Unit-IV **(08 Hours)**

Title: Hydrogen Storage Methods

Hydrogen storage methods - metal hydrides - size effects - hydrogen storage capacity - hydrogen reaction kinetics - carbon-free cycle- gravimetric and volumetric storage capacities - hydriding/dehydriding kinetics - high enthalpy of formation - and thermal management during the hydriding reaction - distinctive chemical and physical properties - multiple catalytic effects - degradation of the sorption properties - hydride storage materials for automotive applications.

Unit-V **(08Hours)**

Title: Environmental Concerns of Nanomaterials

Identification of Nano - Specific Risks- Responding to the Challenge -Human health hazard – Risk reduction – Standards – Safety – transportation of NP– Emergency responders. Risk

assessment –Environmental Impact – Predicting hazard – Materials Characterization. Risk Assessment related to nanotechnology – Environmental and policy making - Ecotoxicity measurement of Polychlirinated biphenyl and intermediates in their degradation Vacuum Packaging under inert gas atmosphere, Methodology for Stabilization, Human safety in Nonmaterial processing area.

Unit-VI **(08 Hours)**

Title: Product Development with Nanomaterials

Criteria for selection of product- Product development process- Design for Manufacture - Estimate the manufacturing cost- Reduce the support cost- Prototyping- Economics of Product development projects - Elements of Economic analysis- financial models - Sensitive analysis and influence of the quantitative factors.

Termwork

At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Books /Text References

1. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986.
2. Hydrogen from Renewable Energy Sources by D. Infield,
3. Fuel Storage on Board Hydrogen Storage in Carbon Nanostructures by R.A. Shatwell,
4. Fuel cell technology handbook. Hoogers. CRC Press, 2003.

5. Handbook of fuel cells: Fuel cell technology and applications by Vielstich. Wiley, CRC Press, 2003.

6. P.P. Simeonova, N. Opopol and M.I. Lus ter, ―Nanotechnology - Toxicological Issues and Environmental Safety‖, Springer 2006.

Syllabus for Unit Test

Unit Test 1- Units I ,II and III

Unit Test 2 -Units IV,V and VI

Elective I: COMPUTATIONAL NANOSCIENCE

TEACHING SCHEME	EXAMINATION SCHEME	
Lectures : 04 Hrs/Week	Theory	: 60 Marks
Practical : 02 Hrs/Week	Duration	: 03 Hours
	Unit Test –I	: 20 Marks
	Unit Test –II	: 20 Marks
	TW/Pract./Oral	: 50 Marks
	Theory Credits	04
	Practical Credits	01

Unit-I **(08 Hours)**

Title: Fundamental Principles Of Numerical Methods

Scientific Modeling - Numerical data and Numerical operations -Numerical Algorithms - Numerical Programs -Numerical Software - Approximations in Mathematical Model building- Numerical integration -Differentiation -Variational finite element methods-Rayleigh's method-Ritz method.

Unit-II **(08 Hours)**

Title: Mathematical Modeling

Mathematical modeling - physical simulation - advantages and limitations - process control - Transport phenomena- concept of physical domain and computational domain - assumptions and limitations in numerical solutions – Finite element method and Finite difference method.

Unit-III **(08Hours)**

Title: Differential Equations & Applications

Euler method, Runge-Kutta method, Multi step-differential equations-boundary values- Elliptic equations-one dimensional parabolic equation-hyperbolic equation- partial differential equations -separation of variables-wave equation-Laplace equation-nonlinear partial differential equations - approximation methods of nonlinear differential equations.

Unit-IV **(08 Hours)**

Title: Simulation

Basic concepts of simulation- data manipulation, data exchange of the structure, properties and processing of materials-Three dimensional model for capillary nanobridges and capillary forces. Molecular dynamics simulation.

Unit-V **(08Hours)**

Title: Monte Carlo Methods

Basics of the Monte Carlo method-Algorithms for Monte Carlo simulation-Applications to systems of classical particles-modified Monte Carlo techniques-percolation system-variation Monte Carlo method-diffusion Monte Carlo method - Quantum Monte Carlo method.

Unit-VI **(08 Hours)**

Title: Nanoscale Modeling and Simulations

Introduction to Matlab and Mathematics (and their open source counterparts-Scilab and Octave); examples from nano-optics and nano-electronics, Molecular dynamics, computing and simulations, Simulations from ab initio to multiscale Modeling, Nanodesign Nano-CAD.

Termwork

At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Books /Text References

1. S.C. Chapra and R.P.Canale, –Numerical methods for Engineers‖, Tata McGraw Hill, New Delhi, 2002.
2. Erwin Kreyzig, –Advanced Engineering Mathematics‖, John Wiley & Sons, 2004.
3. R.J. Schilling and S.L. Harris, –Applied Numerical Methods for Engineers using MATLAB and C‖, Thomson publishers, New Delhi, 2004..
4 D. Frenkel and B. Smith, –Understanding molecular simulation from algorithm to applications‖, Kluwar Academic Press, 1999.
5 K. Ohno, K. Esfarjani and Y. Kawazoe, –Introduction to Computational Materials Science from ab initio to Monte Carlo Methods‖, Springer-Verlag, 1999.

Syllabus for Unit Test

Unit Test 1- Units I ,II and III
Unit Test 2- Units IV,V and VI

Elective I: NANO ELECTRONICS

TEACHING SCHEME	EXAMINATION SCHEME	
Lectures : 04 Hrs/Week	Theory	: 60 Marks
Practical : 02 Hrs/Week	Duration	: 03 Hours
	Unit Test –I	: 20 Marks
	Unit Test –II	: 20 Marks
	TW/Pract./Oral	: 50 Marks
	Theory Credits	04
	Practical Credits	01

Unit-I **(08 Hours)**

Title: Semiconductor Nanodevices

Single-Electron Devices; Nano scale MOSFET – Resonant Tunneling Transistor - Single-Electron Transistors; Single-Electron Dynamics; Nanorobotics and Nanomanipulation; Mechanical Molecular Nanodevices; Nanocomputers: Theoretical Models; Optical Fibers for Nanodevices; Photochemical Molecular Devices; DNA-Based Nanodevices; Gas-Based Nanodevices; Micro and Nanomechanics.

Unit-II **(08 Hours)**

Title: Electronic And Photonic Molecular Materials

Preparation –Electroluminescent Organic materials - Laser Diodes - Quantum well lasers:- Quantum cascade lasers- Cascade surface-emitting photonic crystal laser- Quantum dot lasers- Quantum wire lasers:- White LEDs - LEDs based on nanowires - LEDs based on nanotubes- LEDs based on nanorods High Efficiency Materials for OLEDs- High Efficiency Materials for OLEDs - Quantum well infrared photo detectors.

Unit-III **(08Hours)**

Title: Thermal Sensors

Thermal energy sensors -temperature sensors, heat sensors- Electromagnetic sensors- electrical resistance sensors, electrical current sensors, electrical voltage sensors, electrical power sensors, magnetism sensors - Mechanical sensors -pressure sensors, gas and liquid flow sensors, position sensors - Chemical sensors - Optical and radiation sensors.

Unit-IV **(08 Hours)**

Title: Gas Sensor Materials

Criteria for the choice of materials, Experimental aspects – materials, properties, measurement of gas sensing property, sensitivity; Discussion of sensors for various gases, Gas sensors based on semiconductor devices.

Unit-V **(08Hours)**

Title: Biosensors

Principles- DNA based biosensors – Protein based biosensors – materials for biosensor applications- fabrication of biosensors—future potential

Unit-VI **(08 Hours)**

Title: NanoBio Electronic Systems

Nano Bio Sensors, Bio-Characterization

Termwork

At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Books /Text References

1. W. Ranier, –Nano Electronics and Information Technology‖, Wiley, (2003).
2. K.E. Drexler, –Nano systems‖, Wiley, (1992).
3. M.C. Pettey, –Introduction to Molecular Electronics‖.

Syllabus for Unit Test

Unit Test 1- Units I ,II and III

Unit Test 2 -Units IV,V and VI

Elective I: NANO MEDICINE

TEACHING SCHEME	EXAMINATION SCHEME	
Lectures : 04 Hrs/Week	Theory	: 60 Marks
Practical : 02 Hrs/Week	Duration	: 03 Hours
	Unit Test –I	: 20 Marks
	Unit Test –II	: 20 Marks
	TW/Pract./Oral	: 50 Marks
	Theory Credits	04
	Practical Credits	01

Unit-I **(08 Hours)**

Applications of nano-medicine: Bio- Pharmaceuticals, biological implants, diagnostic tools, Genetic testing – imaging – nanoparticles probe

Unit-II **(08 Hours)**

Microfabricated drug delivery systems: microneedles- micropumps-microvalves-implantable microchips,

Unit-III **(08Hours)**

Nanocarriers : drug delivery : sustained / controlled/ targeted

Unit-IV **(08 Hours)**

Polymeric nanoparticulate systems: polymeric micelles as drug carriers – dendrimers as nanoparticulate drug carriers - nanocapsules preparation, characterization and therapeutic applications

Unit-V **(08Hours)**

Liposomes for genetic vaccines and cancer therapy - recent advances in microemulsions as drug delivery vehicles, lipoproteins as pharmaceutical carriers, solid lipid nanoparticles as drug carriers Tumor detection and targeting in vivo, Gene Therapy using nanoparticles

Unit-VI **(08 Hours)**

Diagnosis, Characterization and Testing of Nano-Bio Systems.

Termwork

At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Practicals:

1. Liposome based delivery of DNA (GFP based vector) in cells and their detection under fluorescence microscope-4
2. Delivery of nanoparticles based drugs in cells-3
3. Isolation of protein, estimation and running of gel, western blotting to detect a particular protein (e.g. p53)- 5

Books /Text References

1. Dr.Parag Diwan and Ashish Bharadwaj (eds) Nano Medicines, Pentagon Press
2. Vladimir P.Torchilin (Ed.) Nanoparticulates as Drug Carriers, Imperial College Press, North Eastern University, USA
3. Drug Delivery: Engineering Principles for Drug Therapy, M. Salzman.
4. Drug Delivery and Targeting, A.M. Hillery, CRC Press.
5. Drug Delivery: Principles and Applications, B. Wang, Wiley Intersceince

Syllabus for Unit Test

Unit Test 1- Units I ,II and III
Unit Test 2- Units IV,V and VI

Elective I: NANO ENGINEERED DEVICES

TEACHING SCHEME	EXAMINATION SCHEME	
Lectures : 04 Hrs/Week	Theory	: 60 Marks
Practical : 02 Hrs/Week	Duration	: 03 Hours
	Unit Test –I	: 20 Marks
	Unit Test –II	: 20 Marks
	TW/Pract./Oral	: 50 Marks
	Theory Credits	04
	Practical Credits	01

Unit-I **(08 Hours)**

Title: Quantum Devices

Quantum Electronic devices – upcoming electronic devices – Electrons in mesocopic structures – Shortchannel MOS Transistor – Split gate transistor – Electron wave transistor – Electron spin transistor –Quantum cellular Automata – Quantum Dot array – Quantum computer- Bit and Qubit – Coherence and Entanglement – Quantum Parallelism.

Unit-II **(08 Hours)**

Title: Tunneling Devices

Tunneling element – Tunnel Effect and Tunneling Elements -Tunneling Diode – Resonant Tunneling Diode – Three -Terminal Resonate Tunneling Devices -Technology of RTD-Digital circuits design based on RTDs –Memory Applications – Basics Logic Circuits – Dynamic Logic Gates - Digital circuits design based on RTBT –RTBT Mobile – RTBT Threshold Gate – RTBT Multiplexer – Single Electron Transistor(SET) – Principle –Coulomb Blockade- Performance – Technology- Circuit Design- Writing and Drivers – Logic and Memory Circuits – SET adder as an Example of a Distributed Circuit – Comparison between FET and SET.

Unit-III **(08Hours)**

Title: Superconducting Devices And Photonics

Basics - Macroscopic characteristics – Macroscopic model- Super conducting switching De vices – Cryotron-Josephson Tunneling Devices - Elementary circuits – Associative or Content – Addressable Memory - SQUID– Flux Quantum device –LC –Gate – Magnetic Flux Quantum – Quantum cellular Automata – Quantum computer with Single Flux devices – SFQD- RSFQD – Application of superconducting devices – Intergrated Electronics – Comparison of FET Electronics. Introduction to Photonics - Principle- Fabrication –application.

Unit-IV **(08 Hours)**

Title: Uncertainty Of Nanodevices

Limits of Integrated Electronics - Survey of Limits – Replacement of Technologies – Energy Supply and Heat Dissipation – Parameter Spread as Limiting Effect – Limits due to Thermal

Particle motion - Debye Length –Thermal Noise- Reliability of as Limiting Factor – Physical limits – Thermodynamic Limits - Relativistic Limits– Equal Failure Rates by Tunneling and Thermal Noise – Final Objectives of Integrated Electronic Systems -Removal of uncertainty by Nanomachines – Uncertainties in Nanosystems - Uncertainties in the Development of Nanoelectronics.

Unit-V **(08Hours)**

Title: Molecular And Bioelectronics

Bioelectronics – molecular processor – DNA Analyser molecular electronics – switches based on fullerenes and nanotubes – polymer electronic – self Assembling circuits – optical molecular memories – DNA computer – Information Processing with chemical reaction – Nanomachines – Parallel Processing - Drexler – Smalley debate – realistic projection- Synergy of Nano-Bio-Info.

Unit-VI **(08 Hours)**

Title: Nanobio Systems

Reference(s) :

1Termwork

At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Books /Text References

1. K. Goser, P. Glosekotter and J. Diens tuhl, ‖Nanoelectronics and Nanosystems -From Transistors to Molecular Quantum Devices‖ , Springer, 2004.
2 Herve Rigneault, Jean-Michel Lourtioz, Claude Delalande, Ariel Levenson, ‖Nanophotonics‖, ISTE.
3. W.R.Fahrner, ‖Nanotechnology and Nanoelectronics – Materials, Devices and Measurement Techniques‖ Springer, 2006.

Syllabus for Unit Test

Unit Test 1- Units I ,II and III
Unit Test 2- Units IV,V and VI

Elective II: NANO PHOTONICS

TEACHING SCHEME
Lectures : 04 Hrs/Week
Practical : 02 Hrs/Week

EXAMINATION SCHEME

Theory	: 60 Marks
Duration	: 03 Hours
Unit Test –I	: 20 Marks
Unit Test –II	: 20 Marks
TW/Pract./Oral	: 50 Marks
Theory Credits	04
Practical Credits	01

Unit-I **(08 Hours)**

Title: Quantum Confined Materials

Quantum dots – optical transitions – absorption-inter-band transitions-quantum confinement intraband transitions-fluorescence/ luminescence–photoluminescence /fluorescence optically excited emission – electroluminescence emission.

Unit-II **(08 Hours)**

Title: Plasmonics

Internal reflection and evanescent waves- plasmons and surface plasmon resonance (SPR)- Attenuated total reflection- Grating SPR coupling- Optical waveguide SPR coupling- SPR dependencies and materials- plasmonics and nanoparticles.

Unit-III **(08Hours)**

Title: New Approaches in Nanophotonics

Near-Field Optics- Aperture near-field optics- Apertureless near-field optics- Near-field scanning optical microscopy (NSOM or SNOM)- SNOM based detection of plasmonic energy transport- SNOM based visualization of waveguide structures- SNOM in nanolithography- SNOM based optical data storage and recovery.

Unit-IV **(08 Hours)**

Title: Biophotonics

Interaction of light with cells- tissues- nonlinear optical processes with intense laser beams- photoinduced effects in biological systems-generation of optical forces-optical trapping and manipulation of single molecules and cells in optical confinement-laser trapping and dissection for biological systems-single molecule biophysics- DNA protein interactions.

Unit-V **(08Hours)**

Title: Photonic Crystals

Important features of photonic crystals- Presence of photonic bandgap- Anomalous Group Velocity Dispersion- Microcavity-Effects in Photonic Crystals- Fabrication of photonic crystals- Dielectric mirrors and interference filters- Photonic Crystal Laser- PC based LEDs- Photonic crystal fibers (PCFs)- Photonic crystal sensing.

Unit-VI **(08 Hours)**

Title: Nanobio Systems

Termwork

At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Books /Text References

1. H.Masuhara, S.Kawata and F.Tokunaga, Nano Biophotonics, Elsevier Science, 2007.
2. V.M. Shalaev and S.Kawata, Nanophotonics with Surface Plasmons (Advances in Nano-Optics and Nano-Photonics), 2007.
3. B.E.A. Saleh and A.C.Teich, Fundamentals of Photonics, John-Weiley & Sons, New York, 1993.
4. M.Ohtsu, K.Kobayashi, T.Kawazoe, and T.Yatsui, Principles of Nanophotonics (Optics and Optoelectronics), University of Tokyo, Japan, 2003.
5. P.N. Prasad, Introduction to Biophotonics, John Wiley & Sons, 2003.
6. J.D.Joannopoulos, R.D.Meade and J.N.Winn, Photonic Crystals, Princeton University Press, Princeton, 1995.

Syllabus for Unit Test

Unit Test 1- Units I ,II and III

Unit Test 2- Units IV,V and VI

Elective II: INDUSTRIAL NANOTECHNOLOGY

TEACHING SCHEME	EXAMINATION SCHEME	
Lectures : 04 Hrs/Week	Theory	: 60 Marks
Practical : 02 Hrs/Week	Duration	: 03 Hours
	Unit Test –I	: 20 Marks
	Unit Test –II	: 20 Marks
	TW/Pract./Oral	: 50 Marks
	Theory Credits	: 04
	Practical Credits	: 01

Unit – I **(08 Hours)**

Title:Product Design

Concept generation- Product Architecture- Industrial Design Process- Management of Industrial design Process and Assessing the quality of Industrial Design - Establishing the product specification

Unit – II **(08 Hours)**

Title: Product Development

Criteria for selection of product- Product development process- Design for Manufacture - Estimate the manufacturing cost- Reduce the support cost- Prototyping- Economics of Product development projects - Elements of Economic analysis- financial models - Sensitive analysis and influence of the quantitative factors.

Unit – III **(08 Hours)**

Title:Management Techniques

Technology Management - Scientific Management - Development of management Thought- Principles of Management- Functions of management-planning- organization- Directing, Staffing and Controlling- Management by objective- SWOT analysis- Enterprise Resource planning and supply chain management.

Unit – IV **(08 Hours)**

Title: Entrepreneurial Competence & Environment

Concept of Entrepreneurship- Entrepreneurship as a career- Personality Characteristic a successful Entrepreneur- Knowledge and skill required for an Entrepreneur- Business environment- Entrepreneurship Development Training - Center and State government policies and Regulations - International Business.

Unit–V Management Of Small Business (08 Hours)

Pre-feasibility study - Ownership - budgeting - project profile preparation - Feasibility Report preparation - Evaluation Criteria- Market and channel selection- Product launching - Monitoring and Evaluation of Business- Effective Management of Small business.

Termwork

At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Reference Books:

1. Karal, T. Ulrich Steven, D. Eppinger, –Product Design and Development‖, McGraw- Hill International, editions, 2003.
2. H. Koontz and H. Weihrich, –Essentials of management‖, McGraw Hill Publishing company, Singapore international edition, 1980.
3. S. Rosenthal, –Effective Product Design and Development‖, Irwin, 1992.
4. Nanotechnology Standards (Nanostructure Science and Technology) by Vladimir Murashov and John Howard (Feb 3, 2011)
5. Introduction to Nanoscience and Nanotechnology by Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta and John J. Moore (Dec 22, 2008)

Text Books:

1. J.J. Massie, –Essentials of Management‖ Prentice Hall of India Pvt. Ltd., 1985.
2. Hisrich, –Entrepreneurship‖ Tata Mc Graw Hill, New Delhi, 2001.
3.Nanotechnology: The Business (Perspectives in Nanotechnology) by Michael T. Burke (Sep 29, 2008)
4. Nanotechnology Demystified by Linda Williams and Wade Adams (Aug 29, 2006)
5. Microsystems and Nanotechnology by Zhaoying Zhou, Zhonglin Wang and Liwei Lin (Nov 28, 2011)

Syllabus for Unit Test

Unit Test 1-- Units I ,II and III
Unit Test 2- Units IV,V and VI

Elective II: NANO MATERIAL SCIENCE

TEACHING SCHEME	EXAMINATION SCHEME	
Lectures : 04 Hrs/Week	Theory	: 60 Marks
Practical : 02 Hrs/Week	Duration	: 03 Hours
	Unit Test –I	: 20 Marks
	Unit Test –II	: 20 Marks
	TW/Pract./Oral	: 50 Marks
	Theory Credits	04
	Practical Credits	01

Unit-I **(08 Hours)**

Title: Physical Properties

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

Unit-II **(08 Hours)**

Title: Physical Chemistry of Solid Surfaces

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

Unit-III **(08Hours)**

Title: Chemistry Aspects

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

Unit-IV **(08 Hours)**

Title: NanoStructures

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

Unit-V **(08Hours)**

Title: Nanosystems

Nanoparticles through homogeneous nucleation-Growth controlled by diffusion-growth controlled by surface process-influences of reduction reagents-solid state phase segregation-kinetically confined synthesis of nanoparticles-template based synthesis.

Unit-VI **(08 Hours)**

Title: Nano Electronics

Quantization of action, charge and flux – electrons in potential well – photons interacting with electrons in solids – diffusion processes – basic information theory – data & bits – data processing - Size Effects on structure and Morphology of free or Supported Nanoparticles – Size and confinement Effects – Fraction of surface atoms – Specific surface energy and surface stress.

Termwork

At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Books /Text References

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

Syllabus for Unit Test

Unit Test 1- Units I ,II and III

Unit Test 2- Units IV,V and VI

Elective II: NANO COMPOSITES

TEACHING SCHEME	EXAMINATION SCHEME	
Lectures : 04 Hrs/Week	Theory	: 60 Marks
Practical : 02 Hrs/Week	Duration	: 03 Hours
	Unit Test –I	: 20 Marks
	Unit Test –II	: 20 Marks
	TW/Pract./Oral	: 50 Marks
	Theory Credits	04
	Practical Credits	01

Unit-I **(08 Hours)**

Title: Metal Based Nanocomposites

Metal Oxide or Metal Ceramic Composites, Different aspects of their preparation techniques, their final properties and functionality.

Unit-II **(08 Hours)**

Title: Polymer Based Nanocomposites

Preparation and Characterization of Diblock Copolymer based nanoconposites; Polymer – Carbon Nanotubes based composites, Their electrical, magnetic and mechanical properties. Polymer Dendrimer based composite .Percolation theory for CNT polymer based nanocomposite. Nanoscale reinforcement:Nanoclays:Carbon Nanomaterials,Polymer Matrix Nanocomposite. Lamellar nanocomposite.Application of different nanocomposite in industries:polymer:textile:automotive etc.,

Unit-III **(08Hours)**

Title: Properties and Characterization of Nanocomposites

Unit-IV **(08 Hours)**

Title: Bionano Composites for Tissue Engineering

Major Physiological systems of current interest to Biomedical Engineers: Cardiovascular, endocrine, nervous, visual, gastrointestinal systems. Tissue Engineering for specific organs such as, Bone marrow, skeletal muscles and cartilage, Cell biological fundamentals of tissue engineering. Application of nanomaterials in biomedical Transplant: architecture , assembly, transportation, nutrients. Concept of transplant and its rejection. Xenotransplantation. Imaging of cancer cells, Tissue imaging by QD, Nanoparticals: principles process, application .MRI.

Unit-V **(08Hours)**

Title Manufacturing of Bionanomaterials

Natural and artificial (Microbial Nanoparticles production,Viral Nanoparticles production, Plant and diatoms Nanoparticles production), DNA, peptide, Protein ,enzyme based manufacturing: Application: architecture: electronics, (Topdown, Bottom up):Devices, Nano particles with

biosystems ,Natural biocomposite :spider silk:Bone :shells,CNT based biomaterials: using cnt as a template, Biosensors:using Nano materials with bio systems(Plant and animal cell,DNA,microtubules,antibodies,antigens etc..).Cellular imaging. Bionanoarrays: DNA, Protein, nucleotide based, viruses . DNA based computation . DNA as functional template for nanocircuitry. Nanomotors. Cellular nanosystem interaction :concept, process ,application,Biochip. Magnetic Nanoparticle by bacteria:mechanism of formation, application.

Unit-VI **(08 Hours)**

Title: Properties and Characterization of Bionanomaterials

Use of AFM, SEM , TEM, XRD based bionanomaterial characterization, Properties of DNA structure as nanotechnology aspects, Surface modification properties of Cell, antibodies, antigens, proteins, enzymes.

Termwork

At least Eight Assignment based on above syllabus

Oral

Term work and oral will be based on above syllabus.

Books /Text References

1. Nanocomposite Science & Technology Ajayan, Schadler & Braun
2. Nanocomposites, By Challa S. S. R. Kumar, John Wiley & Sons.
3. Nanostructured Materials: Selected Synthesis Methods, Properties, and Applications, Philippe Knauth, Joop Schoonman
4. Polymeric Nanocomposites: Theory and Practice, By Sati N. Bhattacharya, Musa Rasim Kamal, Rahul K. Gupta, Hanser Verlag
5. Polymer Nanocomposites: Processing, Characterization, And Application, McGraw-Hill Prof Med/Tech
6. Introduction to Nanocomposite Materials: Properties, Processing, By Thomas E. Twardowski, Thomas Twardowski, DEStech Publications, Inc.
7. Nanobiotechnology II more concept and application chad A. Mirkin and christof M.niemeyer Publi WILY WH.
8. **Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology** - Hari Singh Nalwa.
9. **Bionanotechnology: Lessons from Nature** by David S. Goodsell.

Syllabus for Unit Test

Unit Test 1- Units I ,II and III

Unit Test 2- Units IV,V and VI

SELF STUDY-I
MODELING AND SIMULATION OF NANOSYSTEMS

TEACHING SCHEME	EXAMINATION SCHEME	
Lectures: 04 Hrs/Week	Duration	: 03 Hours
	Theory	: 60 Marks
	Internal Assessment	: 40 marks
	Theory Credits	04

Unit I:

Introduction to modeling and simulation

Abstract, what is modeling? ,What is simulation?, How to develop a simulation model, How to design a simulation experiment, how to perform simulation analysis, what makes a problem suitable for simulation modeling and analysis, How to select simulation software, benefits of simulation modeling and analysis, what are some pitfalls to guard against in simulation.

Unit II:

Computer Modeling of Nanostructured material

Introduction, Modeling Methods: Molecular dynamics and Monte Carlo Modeling, atomic potential energies and Forces, Multiscale Modeling, Nanostructured Materials: Nanoparticle properties

Unit III:

Microstructure Modeling

Microstructure Modeling, Sintering and grain growth dynamics, mechanical deformation and fracture, shock loading, irrational properties, Nan alloys, Prospects for future modeling

Unit IV:

Molecular Dynamics:

Overview, Nano statistical mechanics, Fundamentals of Molecular Dynamics

Unit V:

Software's for Molecular Dynamics Modeling

Principles of Nano Modeling, PES revisited, accuracy requirements, conclusions

Unit VI:

Application: Nanorobot modeling and simulation

Abstract, introduction, blood components, nanorobot modeling and design, nanorobot simulation

Books /Text References

1. Nanostructure material by Carl C. Koch
2. Nanosystems by K.Eric Drexler

Syllabus for Unit Test

Unit Test-1	Units- I ,II and III
Unit Test-2	Units -IV,V and VI

SYNTHESIS AND DESIGN OF NANOSCALE PRODUCTS

TEACHING SCHEME	EXAMINATION SCHEME	
Lectures: 04 Hrs/Week	Duration	: 03 Hours
	Theory	: 60 Marks
	Internal Assessment	: 40 marks
	Theory Credits	04

Unit I:

Fundamental concepts of Nanoscale materials, various types of nanomaterials used in Nanotechnology such as CNTs, fullerenes, nanorods, metal oxides, quantum dots, etc.

Unit II:

Approaches such as top-down approach, bottom up approach, biomimetic and functional approach to construct nanomaterials

Unit III:

Nanomaterials related to nanoionics and nanoelectronics, Reticular synthesis and the design of new materials, Synthesis of highly ordered mesoporous materials from layered polysilicates, Flexible Synthesis of Composite Aerogels

Unit IV:

Nanoscale integrated three dimensional circuits

Unit V:

Nanoscale materials for bulk applications

Unit VI:

Toxicological aspects of nanoscaled materials

Books /Text References

1. Mick Wilson, Kamali Kannargare., Geoff Smith, ‒Nano technology: Basic Science and Emerging technologies‖, Overseas Press, 2005.
2. Nanostructures and Nanomaterials: synthesis, properties and applications, G. Cao and Y. Wang, World Scientific, 2nd edition, 2011
3. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate (Eds.), Handbook of NanoScience, Engg. and Technology, CRC Press, 2002.
4. K. Barriham, D.D. Vvedensky, Low dimensional semiconductor structures: fundamental and device applications, Cambridge University Press, 2001.
5. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties &Applications, Imperial College Press, 2004.

Syllabus for Unit Test

Unit Test-1	Units- I ,II and III
Unit Test-2	Units -IV,V and VI

APPLICATIONS OF NANOTECHNOLOGY IN FOOD AND AGRICULTURE

TEACHING SCHEME	EXAMINATION SCHEME	
Lectures: 04 Hrs/Week	Duration	: 03 Hours
	Theory	: 60 Marks
	Internal Assessment	: 40 marks
	Theory Credits	04

Unit I:

Use of nanotechnologies in the agriculture sector

Precision farming for basic agriculture, real time monitoring of soil conditions, combating the crop pathogens and the treatment of waste

Unit II:

Strategic applications of Nanotechnology in agriculture

Development of innovative products in food production, processing, preservation and packaging and applications in agriculture, animal feed and agrochemicals, disease detection tools, targeted treatments

Unit III:

Impact of nanotechnologies in the food sector

Nanotechnology-based food and health food products and food packaging materials, Nano-enabled food contact materials (FCMs) and packaging, Polymer composites with various nanomaterials, coatings containing nanoparticles

Unit IV:

Nanosensors in food sector

Intelligent packaging concepts based on nanosensors, use of nanodiagnostic tools for detection and monitoring in food production, sensing applications, biosensors for detection of herbicides, pesticides and pathogens

Unit V:

Encapsulation technology for nanodelivery systems

Use of micelles, liposomes or biopolymer-based carrier systems, processed nanostructures, inorganic and organic nanomaterials in health food products, surface functionalized nanomaterials

Unit VI:

Health aspects

Assessment of human health risks associated with the use of nanotechnologies and nanomaterials in the food and agriculture sectors, safety, current risk assessment approaches used by FAO/WHO, environmental, ethical, policy and regulatory issues

Books /Text References:

1. Nanotechnology in the Agri-food Sector, Lynn J. Frewer , Willem Norde, Arnout Fischer and Frans Kampers, 2011
2. Bionanotechnology: Lessons from Nature by David S. Goodsell
3. Nanomedicine, Vol. IIA: Biocompatibility by Robert A. Freitas
4. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology - Hari Singh Nalwa
5. Nanobiotechnology; ed. C.M. Niemeyer, C.A. Mirkin.

Syllabus for Unit Test

Unit Test-1	Units- I ,II and III
Unit Test-2	Units -IV,V and VI

FINITE ELEMENT METHODS FOR NANOSCALE STRUCTURES

TEACHING SCHEME
Lectures: 04 Hrs/Week

EXAMINATION SCHEME

Duration	: 03 Hours
Theory	: 60 Marks
Internal Assessment	: 40 marks
Theory Credits	04

UNIT I:

Calculus of variation, Introduction to calculus of variations, Introduction to equilibrium equations in elasticity, Euler's Lagrange's equations, Principal of virtual work, virtual displacements, Principles of minimum potential energy, boundary value, initial value problems, Flexibility approach, Displacement approach, Different problems in structural analysis

UNIT II:

FEM Procedure, Derivation of FEM equations by variation principle polynomials, Concept of shape functions, Derivation for linear simplex element, Need for integral forms, Interpolation polynomials in global and local coordinates

UNIT III:
Weighted residual Methods: Concept of weighted residual method, Derivation of FEM equations by Galerkin's method, Solving cantilever beam problem by Galerkin's approach Derivation of shape functions for CST triangular elements, Shape functions for rectangular elements, Shape functions for quadrila1.eral elements.

UNIT IV:
Higher order Elements: Concept of iso-parametric elements, Concept of sub-parametric and super -parametric elements, Concept of Jacobin matrix.
Numerical Integration: Numerical Integration, one point formula and two point formulas

UNIT V:
Different problems of numerical integration evaluation of element stiffness matrix, Automatic mesh generation schemes, Pascal's triangle law for 2D shape functions polynomial, Pascal's triangle law for 3D shape function polynomials, Shape function for beam elements, Hermite shape functions

UNIT VI:

Convergence: Convergence criteria, Compatibility requirements, Geometric isotropy Invariance, Shape functions for iso-parametric elements, Special characteristics of stiffness matrix, direct method for deriving shape functions using Langrage's formula, Plane stress problems

Books /Text References:

1. J.J. Massie, ‐Essentials of Management‖ Prentice Hall of India Pvt. Ltd., 1985.
2. Hisrich, ‐Entrepreneurship‖ Tata Mc Graw Hill, New Delhi, 2001.
3. Nanotechnology: The Business (Perspectives in Nanotechnology) by Michael T. Burke (Sep 29, 2008)
4. Nanotechnology Demystified by Linda Williams and Wade Adams (Aug 29, 2006)
5. Microsystems and Nanotechnology by Zhaoying Zhou, Zhonglin Wang and Liwei Lin (Nov 28, 2011)

Syllabus for Unit Test

Unit Test-1	Units- I ,II and III
Unit Test-2	Units -IV,V and VI

MEMS &NEMS

TEACHING SCHEME
Lectures: 04 Hrs/Week

EXAMINATION SCHEME

Duration	: 03 Hours
Theory	: 60 Marks
Internal Assessment	: 40 marks
Theory Credits	04

UNIT I:
Introduction
Basic Electronics, Application of Electronics to Mechanical Systems, Various Micro Mechano-Electronic Systems, Various Nano Mechano-Electronic Systems, Components and Applications

UNIT II:
Micro-electromechanical Systems (MEMS)
What is MEMS? Definitions and Classifications, History, Applications, Established MEMS Applications New MEMS Applications, MEMS Market Miniaturization Issues

UNIT III:
MEMS Fabrication Methods
Photolithography, Materials for Micromachining Substrate ,Additive Films and Materials, Bulk Micro machining ,Wet Etching, Dry Etching ,Surface Micro machining , Fusion Bonding, High-Aspect-Ratio-Micromachining,

UNIT IV:
NEMS Fabrication Methods
LIGA, self assembling system, Molecular Manipulation, Laser Micromachining, 3Computer Aided Design, Assembly and System Integration, Packaging, Multi-Chip Modules, Passivation and Encapsulation, Foundry Services

UNIT V:
Applications
MEMS Transducers, Piezoelectric MEMS, Interstitial MEMS, Biochemical analysis, Power MEMS, Acoustical MEMS, Microreactors, Optical MEMS

UNIT VI:
Future of MEMS
Industry Challenges, the Way Ahead, NEMS

Books /Text References/Web Site:

1. An Introduction to MEMS (Micro-electromechanical Systems) – By PRIME Faraday Partnership

   http://www.amazon.co.uk/exec/obidos/ASIN/1844020207

2. MEMS and NEMS: Systems, Devices, and Structures. Sergey Edward Lyshevski, Rochester Institute of Technology, New York, USA. CRC Press, 2002.
3. Development of micro-diesel injector nozzles via MEMS technology and effects on spray characteristics Seunghyun Baik, James P. Blanchard and Michael L. Corradini (Pdf files)

Syllabus for Unit Test

Unit Test-1	Units- I ,II and III
Unit Test-2	Units -IV,V and VI

SELF STUDY-II
SILICON NANOSTRUCTURES & CARBON NANOTUBES BASED NANOELECTRONICS

TEACHING SCHEME	EXAMINATION SCHEME	
Lectures: 04 Hrs/Week	Duration	: 03 Hours
	Theory	: 60 Marks
	Internal Assessment	: 40 marks
	Theory Credits	04

Unit I:
Semiconductor Nanostructures & Nanomaterials

Semiconductor Nanostructures & Nanomaterials: Introduction, Importance of Semiconductor Nanomaterials in Electronic Industry, Various Silicon Nanostructures, Silicon Nanowires

Silicon Quantum Dots, Silicon Nanotubes, Hybrid Silicon-Carbon Nanotubes

Silicon Carbide Nanotubes

Unit II:

Carbon Nanotubes Nanoelectronics

Carbon Nanotubes: Introduction, Synthesis of Carbon Nanotubes, Properties of Carbon Nanotubes, Specific Applications in Electronics, Carbon Nanotube based Field Emission Devices, Carbon Nanotube Transistors, Single Electron Transistor, Ballistic Carbon Nanotube Field Effect Transistor with Palladium Contact

Unit III:

Carbon Nanotubes: Nanoelectronics

Overview of Carbon Nanotube Field Effect Transistor Technology

Unit IV:

Notable Achievements in Nanoelectronics

Single-Molecule Electronics: Molecular electronics, Molecular logic gate, Molecular wires

Solid State Nanoelectronics: Nanocircuitry, Nanolithography, Nanosensors

Unit V:

Silicon Nanotechnology

Silicon Nanotechnology: CMOS Nanotechnology, Ballistic Properties, Memory

Unit VI:

Display Devices

Nano Emissive Display Devices, Quantum Dots, Nano Chips

Nano Electro Mechanical System (NEMS)

Books /Text References:

1. Nanotechnology Demystified by Linda Williams and Wade Adams (Aug 29, 2006)
2. Microsystems and Nanotechnology by Zhaoying Zhou, Zhonglin Wang and Liwei Lin (Nov 28, 2011)
3. Polymeric Nanocomposites: Theory and Practice, By Sati N. Bhattacharya, Musa Rasim Kamal, Rahul K. Gupta, Hanser Verlag
4. Polymer Nanocomposites: Processing, Characterization, And Application, McGraw-Hill.

Syllabus for Unit Test

Unit Test-1	Units- I ,II and III
Unit Test-2	Units -IV,V and VI

SELF STUDY II

Subject: Nanobioelectronics

Unit I

Semiconductor Fabrication – Top-down techniques

Unit II

Introduction to Semiconductor and Carbon-based nanostructures
Introduction to Carbon-based electronic devices

Unit III

Electrical transport at nanoscale
Coupling of biology and nanoelectronics

Unit IV

Biorecognition and transduction events
Biosensors - Electrochemical and Impedance-based methods

Unit V

DNA bioelectronics
Protein (biomimetic) based nanodevices

Unit VI

Current applications in cancer, regenerative medicine, neuroscience,

SELF STUDY II

Subject: Compound Semiconductor Materials and Devices

Unit I

Introduction to the Compound semiconductor materials and devices

Miller Indices,Reciprocal lattice vector-1,Reciprocal vector -2.

Unit II

Bragg Diffraction-1, Bragg Diffraction-2.

BrillouinZone,Bandstructure, Effective Mass,Infinite Quantum Well.

Unit III

DOS of Nanostructure-1,DOS of Nanostructure-2,Finite Quantum Well-1.

Finite Quantum Well-2, Tringular Well-1, Tringular well-2,

Double Quantum well-1, Double Quantum Well-2.

Unit IV

Bloch Theorem, Superlattice-1,Supperlattice-2.

Heterostructure strain, Band gap engineering.

Unit V

Band alignment, anion rule, Auger recombination.

Unit VI

Long wavelength infrared photodetectors, Quantum cascaded lasers

SELF STUDY II

Subject: Nanoprocessing

Unit I

Introduction, Characterization and manipulation at nano-scale

Scanning electron microscope (SEM)
Transmission electron microscope (TEM)

Unit II

Scanning probe microscope (SPM)
Scanning tunneling microscope (STM)
Atomic force microscope (AFM)

Unit III

X-ray diffraction
Synthesis and processing 0D nanostructures – nanoparticles

Unit IV

Homogeneous nucleation
Synthesis of metallic nanoparticles
Synthesis of nonoxide semiconductor nanoparticles
Synthesis of oxide nanoparticles
Vapor phase synthesis
Solid-state synthesis

Unit V

Heterogeneous nucleation
Spatially confined growth
Core-shell nanoparticles

Unit VI

Synthesis and processing 1D nanostructures – nanowires/nanorods/nanotubes/nanofibers
Bottom-up approaches: Anisotropic growth

Top-down approach – electrospinning

Synthesis and processing 2D nanostructures – thin films
Vapor phase deposition
Liquid phase growth

SELF STUDY PAPER II: SEM IV

Subject: Introduction to Nano-modelling

Unit I

Computational Modelling – Process, Model, Mathematical Model, Methods of Computational Modelling, application to nano-engineering

Unit II

Molecular Dynamic – Modelling & Simulation, Analysis background, Potential Energy Function, Naoscale phenomena, approach to technique

Molecular mechanic – basic aspect, Mechanics of systems of particles, General co-ordinate system, Least Action Principle

Unit III

Energy Minimization - Concept, Methods - First order minimization, Second Order Minimization, Simplex Minimization. Application to molecular dynamic

Unit IV

Statistical Mechanics in Molecular Dynamics – Definition, Ensemble – Micro canonical, Canonical, Isobaric-Isothermal, MD and Time average, Ensemble average

Unit V

Boundary in MD – Periodic Boundary Condition – Fixed simulation cell, semi rigid atomistic boundary

Unit VI

MD Packages - GROMACS – Flow Chart, Computational Lab practical to use of this package