Course Number and Title: NTC-6100 Fundamentals of Nanotechnology
Credits: 4
Course Category: Departmental Core (I Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-G-P): 3-1-0
Type of Course: Theory
Course Assessment:
- Home Assignments (including MATLAB based problems and Quizzes) (15%)
- Mid-Sem Examination (1 hour) (25%)
- End-Sem Examination (2 hours) (60%)

Course Outcomes (COs)

Fundamentals of Nanotechnology

After completion of this course, students shall be able to:
1. Understand the history, background and nature of nanoscience and nanotechnology as well as the quantum and nanosized scale effects on materials.
2. Understand the ethical aspects of nanotechnology.
3. Get acquainted with the relation between biological materials and nanotechnology.
4. Acquire theoretical understanding of different types of carbon materials and its application in nanotechnology.

Syllabus:

UNIT 1: Introduction
Review of Nanotechnology, Ideas about building things with atom, possible application in Science & Technology, Ethical aspects of Nanotechnology.

UNIT 2: Self Assembly and Catalysis

UNIT 3: Biological Materials
Introduction, Biological Building Blocks, Size of building Blocks and Nanostructures, Polypeptide Nanowires and Protein Nanoparticle, Nucie Acids, DNA Double Nanowire, Genetic Code and Protein Synthesis, Biological nanostructures, Examples of Proteins, Miscells and Vesicles, Mutilayer Films.

UNIT 4: Quantum Wells, Wires and Dots
UNIT 5: Nanotechnology in Carbon Materials
Fullerene and Carbon Nanotubes, Fullerene as nano-structures, structures of $\text{C}_{60}$, $\text{C}_{70}$ and higher fullerenes, Electronic properties of fullerenes, Carbon Tubules as Nano-structures, Observation of Carbon Nanotubes, Structure of carbon Nanotubes, Electronic structure of C-Nanotubes.

Books and References:

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Where H=100%, M=75% & L=50%
Course Number and Title: NTS-6110 Quantum Mechanics
Credits: 4
Course Category: Engineering Sciences (I Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-G-P): 3-1-0
Type of Course: Theory
Course Assessment: Home Assignments (including MATLAB based problems and Quizzes) (15%)
Midsem Examination (1 hour) (25%)
Endsem Examination (2 hours) (60%)

Course Outcomes (COs)

Quantum Mechanics
After completion of this course, students shall be able to:
1. understand a working knowledge of the foundations, techniques and key results of quantum mechanics
2. become aware of the necessity for quantum methods in the analysis of physical systems of atomic and solid state physics
3. Appreciate the applications of quantum mechanics in physics, engineering, and related fields
4. understand scientifically the new applications of quantum physics in computation
5. gain advanced studies involving applications of quantum mechanics

Syllabus

UNIT 1: Introduction
Wave-particle duality, Schrödinger equation and expectation values, Uncertainty principle

UNIT 2: Basics Of Quantum Mechanics
Solutions of the one-dimensional Schrödinger equation for free particle, particle in a box, particle in a finite well, linear harmonic oscillator. Reflection and transmission by a potential step and by a rectangular barrier.

UNIT 3: Solution Of Time Independent Schrödinger Equation At Higher Dimensions And More Complicated Systems
Particle in a three dimensional box, linear harmonic oscillator and its solution, density of states, free electron theory of metals. The angular momentum problem. The spin half problem and properties of Pauli spin matrices.

UNIT 4: Approximate Methods
Time independent and time dependent perturbation theory for non-degenerate and degenerate energy levels, the variational method, WKB approximation, adiabatic approximation, sudden approximation.
UNIT 5: Quantum Computation
Concept of quantum computation, Quantum Qbits etc.

Books And References

1. Modern Physics - Beiser
2. Quantum Mechanics - Bransden and Joachen
4. Quantum Physics – A. Ghatak
5. Principles of Quantum Mechanics 2nd ed. - R. Shankar
6. Quantum Mechanics - Vol 1&2 - Cohen-Tannoudji

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**Course Number and Title**: NTE-6120 PHYSICS AND CHEMISTRY OF SOLIDS  
**Credits**: 4  
**Course Category**: Departmental Elective (I Semester)  
**Pre-requisite(s)**: Basic Knowledge of Mathematics  
**Contact Hours (L-G-P)**: 3-1-0  
**Type of Course**: Theory  
**Course Assessment**:  
- Home Assignments (including MATLAB based problems and Quizzes) (15%)  
- Midsem Examination (1 hour) (25%)  
- Endsem Examination (2 hours) (60%)  

**Course Outcomes (COs)**

**Physics and Chemistry of Solids**  
*After completion of this course, students shall be able to:*  
1. analyze their experimental results in terms of structural, electrical properties and the effect of different imperfections on them  
2. Apply core concepts in solids to solve engineering problems and possess the skills and techniques necessary for modern materials engineering practice  
3. understand the professional and ethical responsibilities of a solid state physicist and engineer

**Syllabus**

**UNIT 1: Structure Of Matter**  
Amorphous, crystalline, crystals, polycrystals, symmetry, Unit Cells, Crystal Structures (Bravais Lattices), Crystallographic Directions, Crystallographic Planes, Miller Indices, Bragg’s Law, Single Crystal and Powder X-ray Diffraction

**UNIT 2: Chemical Bonding**

Atomic Bonding in solids, Types of bond: Metallic, Ionic, Covalent and Vender-Waals bond; Hybridisation; H- bonding Molecular orbital theory for simple molecules such as diatomic molecule etc.

**UNIT 3: Types Of Material**

Different types of materials: Metals, Semiconductors, Composite materials, Ceramics, Alloys, Polymers.

**UNIT 4: Imperfections In Solids**

Imperfections of crystal structure: point defects, Grain boundaries, phase boundaries, Dislocations Screw, Edge and Mixed Dislocations generation of defects by quenching, by plastic deformation and by radiation, interaction between point defects and dislocations.
Books And References

1. Introduction to Solid State Physics - C. Kittel
4. Elements materials science - Van Vlack
5. The Physics and Chemistry of Solids - Stephen Elliott & S. R. Elliott

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</table>
Course Number and Title: NTE-6130 Elements of Physical Chemistry
Credits: 4
Course Category: Departmental Elective (I Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-G-P): 3-1-0
Type of Course: Theory
Course Assessment:
- Home Assignments (including MATLAB based problems and Quizzes) (15%)
- Mid sem Examination (1 hour) (25%)
- End sem Examination (2 hours) (60%)

Course Outcomes (COs)

Elements of Physical Chemistry
After completion of this course, students shall be able to:
1. understand the foundation of physical chemistry
2. realizes the importance of thermodynamics which is the main gradient of this course in nanotechnology and in fact in any technology.
3. Apply the thermodynamic reasoning in the synthesis of nanomaterials

Syllabus

UNIT 1: Introduction To Thermodynamics
The first and second laws of thermodynamics. Thermodynamic functions, heat capacity, enthalpy, entropy. Equilibrium in one phase system, real gasses, the reactions between gases, reactions of solid-state phases, Phase rule, Phase diagram, reaction kinetics, rate equations.

UNIT 2: Elementary Statistical Mechanics

UNIT 3: Theory Of Solution And Related Topics

UNIT 4: Diffusion
Fick’s Law, mechanisms of diffusion; generation of point defects; self-diffusion; the influence of the pressure and pressure gradient; Kirkendall effect; fast diffusion; influence of isotropic state; experimental methods of investigation of diffusion.
UNIT 5:Phase Transformations  Mechanisms of phase transformation; homogeneous and heterogeneous nucleation; spinodal decomposition; grain growth; precipitation in solid solution; transformation with constant composition; order-disorder transformations; Martensitic transformation.

Books And References

1. Thermodynamics and Statistical Mechanics - A N Tikhonov, Peter T Landberg, Peter Theodore Landsberg
2. Thermodynamics and Statistical Mechanics by John M. Seddon, J. D. Gale
3. Thermodynamics by Zymansky Statistical Physics by K. Huang
5. Physical Chemistry – Atkins Peter, Paula Julio
6. Physical Chemistry, 1st Edition -Ball

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# Course Information

**Course Number and Title**: NTC-6140  Synthesis and characterization of Nanomaterials

**Credits**: 4

**Course Category**: Departmental Core (I Semester)

**Pre-requisite(s)**: Basic Knowledge of Mathematics

**Contact Hours (L-G-P)**: 3-1-0

**Type of Course**: Theory

**Course Assessment**: Home Assignments (including MATLAB based problems and Quizzes) (15%), Midsem Examination (1 hour) (25%), Endsem Examination (2 hours) (60%)

## Course Outcomes (COs)

**Synthesis and characterization of Nanomaterials**

*After completion of this course, students shall be able to:*

1. familiarise the student with various existing techniques used in nanotechnology
2. understand the physical principles/concepts involved in fabrication of the materials at nano scale
3. fabricate/synthesize the nano material in the laboratory
4. characterize the prepared materials with different available technique

## Syllabus

### UNIT 1: Physical Methods

Inert gas condensation, Arc discharge, RF-plasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapour deposition method and other variants, Electro deposition.

### UNIT 2: Chemical Methods

Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Sonochemical routes, Liquid-liquid interface, Hybrid methods, Solvated metal atom dispersion, Post-synthetic size-selective processing. Sol-gel, Micelles and micro emulsions, Cluster compounds.

### UNIT 3: Biological Methods

Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis.
UNIT 4: Characterization Techniques

X-ray diffraction, Scanning Probe Microscopy, SEM, TEM, Optical microscope and their description, operational principle and application for analysis of nanomaterials, UV-VIS-NIR Spectrophotometers, Principle of operation and application for band gap measurements, Magnetic and electrical measurements.

UNIT 6: Lithographic Techniques


Books And References

2. Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens
5. Springer Handbook of Nanotechnology - Bharat Bhusan
6. Instrumental Methods of Analysis, 7th edition - Willard, Merritt, Dean, Settle
7. Processing & properties of structural nano materials by Leon L. Shaw (editor)
8. Chemistry of nano materials : Synthesis, properties and applications by CNR Rao et.al.
10. Advanced X-ray Techniques in Research and Industries - A. K. Singh (Editor)
14. Fabrication of fine pitch gratings by holography, electron beam lithography and nano-imprint lithography (Proceedings Paper) Author(s): Darren Goodchild; Alexei Bogdanov; Simon Wingar; Bill Benyon; Nak Kim; Frank Shepherd

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Course Number and Title: NTC-6150 Nanobiotechnology
Credits: 4
Course Category: Departmental Core (II Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-G-P): 3-1-0
Type of Course: Theory
Course Assessment: Home Assignments (including MATLAB based problems and Quizzes) (15%)
Midsem Examination (1 hour) (25%)
Endsem Examination (2 hours) (60%)

Course Outcomes (COs)

NTC-6150 Nanobiotechnology
After completion of this course, students shall be able to:
1. understand the structure and function of basic biological entity
2. get familiarized with the biological synthesis of Nanoparticles.
3. designing nanoparticle-biomolecule hybrid systems for bioelectronics devices
4. understand the idea of therapeutic application of nanoparticles and nanodevices evaluate implications in medical applications and Tissue engineering.

Syllabus

UNIT 1: Introduction
Structure and organization of typical animal cell, dimensions of biomolecules and cells, structure and conformational properties of protein, nucleic acid and other biomolecules, cell surface receptor and their specific ligands, antigen antibody interaction, blood brain barrier

UNIT 2: Micro Organisms for Synthesis of Nanomaterials and for Toxicity Detection
Natural and artificial synthesis of nanoparticles in micro Organisms; Use of microorganisms for nanostructure formation, Testing of environmental toxic effect of nano particles using microorganisms;

UNIT 3: Nanocomposite Biomaterials, Teeth and Bone Substitution
Natural nano composite systems as spider silk, bones, shells; organic-inorganic nano composite formation through self-assembly. Biomimetic synthesis of nano composite material; Use of synthetic nano composites for bone, teeth replacement.

UNIT 4: Nanobio Systems
Nanoparticle-biomaterial hybrid systems for bioelectronic devices, Bioelectronic systems based on nanoparticle-enzyme hybrids; nanoparticle based bioelectronic biorecognition events. Biomaterial based metallic nanowires, networks and circuitry. DNA as functional template for nanocircuitry; Protein based nanocircuitry; Neurons for network formation. DNA
nanostructures for mechanics and computing and DNA based computation; DNA based nanomechanical devices. Biosensor and Biochips.

UNIT 5: Drug Delivery, Therapeutic Action of Nanoparticles and Nanodevices
Targeted, non-targeted delivery; controlled drug release; exploiting novel delivery routes using nanoparticles; gene therapy using nanoparticles; Nanostructures for use as antibiotics; Diseased tissue destruction using nanoparticles;

UNIT 6: Diagnostics using Nanomaterial, Nanoparticles for Bio analytical applications
Nanodevices for sensing and therapy. Use of nanoparticles for MRI, X Ray, Ultrasonography, Gamma ray imaging. Nanoparticles as molecular labels; biological labeling using quantum dots as molecular labels;

UNIT 7: Tissue Engineering
Major physiologic systems of current interest to biomedical engineers: cardiovascular, endocrine, nervous, visual, auditory, gastrointestinal, and respiratory. Useful definitions. The status of tissue engineering of specific organs, including bone marrow, skeletal muscle, and cartilage. Cell biological fundamentals of tissue engineering

Books And References
1. Bionanotechnology: Lessons from Nature by David S. Goodsell
3. Handbook of Nanostructured Biomaterials and Their applications in Nanobiotechnology- Hari Singh Nalwa
5. Nanocomposite Science & Technology Ajayan, Schadler & Braun
6. BioMEMS (Microsystems) - Gerald A. Urban
7. Introduction to Nanoscale Science and Technology (Nanostructure Science and Technology) - Massimiliano Di Ventra
8. Springer Handbook of Nanotechnology - Bharat Bhushan

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Course Number and Title : NTC-6160 Properties of Nanomaterials

Credits : 4
Course Category : Departmental Core (II Semester)
Pre-requisite(s) : Basic Knowledge of Mathematics
Contact Hours (L-G-P) : 3-1-0
Type of Course : Theory
Course Assessment : Home Assignments (including MATLAB based problems and Quizzes) (15%)
Midsem Examination (1 hour) (25%)
Endsem Examination (2 hours) (60%)

Course Outcomes (COs)

NTC-6160 Properties of Nanomaterials
After completion of this course, students shall be able to:

1. understand the concept of various kinds of account different properties in terms of variation of size of the particles
2. express their results in terms of quantum mechanical confinement which are occurring below certain size of the particle
3. design and manipulate nanomaterials in terms of their particle size

Syllabus

UNIT 1: Introduction
Properties of materials & nanomaterials, role of size in nanomaterials.

UNIT 2: Electronic Properties
Classification of materials: Metal, Semiconductor, Insulator, Band structures, Brillouin zones, Mobility, Resistivity, Relaxation time, Recombination centers, Hall effects.

UNIT 3: Confinement and Transport in Nanostructure
Current, reservoirs, and electron channels, conductance formula for nanostructures, quantized conductance. Local density of states. Ballistic transport, Coulomb blockade, Diffusive transport, Fock space.

UNIT 4: Dielectric Properties
Polarization, ferroelectric behaviour.

UNIT 5: Magnetic Properties
UNIT 6: Optical Properties
Photoconductivity, Optical absorption & transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence.

UNIT 7: Thermal Properties
Concept of phonon, Thermal conductivity, Specific heat, Exothermic & endothermic processes.

UNIT 8: Mechanical Properties

Books And References
1. Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor
3. Encyclopedia of Nanotechnology- Hari Singh Nalwa
4. Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens
6. Physics of Magnetism - S. Chikazumi and S.H. Charap
7. Physical Theory of Magnetic Domains - C. Kittel
8. Magnetostriction and Magnetomechanical Effects - E.W. Lee
9. Springer Handbook of Nanotechnology - Bharat Bhusan
10. Electronic transport in mesoscopic systems, Supriyo Datta

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Course Number and Title: NTE-6170 Nanocomposites
Credits: 4
Course Category: Departmental Elective (II Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-G-P): 3-1-0
Type of Course: Theory
Course Assessment:
   - Home Assignments (including MATLAB based problems and Quizzes) (15%)
   - Midsem Examination (1 hour) (25%)
   - Endsem Examination (2 hours) (60%)

Course Outcomes (COs)

NTE-6170 Nanocomposites
After completion of this course, students shall be able to:
1. Nanocomposites and explore different aspects of their preparation techniques
2. Discuss various properties of nanocomposites and study mechanical properties of super hard nanocomposites
3. Design super hard nanocomposites
4. Learn about preparation and characterization of polymer based nanocomposites

Syllabus

UNIT 1: Metal based nanocomposites
Metal-Oxide or Metal-Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality.

Metal-metal nanocomposites, some simple preparation techniques and their new electrical and magnetic properties.

UNIT 2: Design of Super hard materials
Super hard nanocomposites, its designing and improvements of mechanical properties.

UNIT 3: New kind of nanocomposites
Fractal based glass-metal nanocomposites, its designing and fractal dimension analysis.
Electrical property of fractal based nanocomposites. Core-Shell structured nanocomposites.

UNIT 4: Polymer based nanocomposites
Preparation and characterization of diblock Copolymer based nanocomposites; Polymer-carbon nanotubes based composites, their mechanical properties, and industrial possibilities.
Books and References:
1. Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V. Braun
2. Physical Properties of Carbon Nanotubes - R. Saito
4. The search for novel, superhard materials - Stan Vepršek (Review Article) JVST A, 1999
5. Electromagnetic and magnetic properties of multi component metal oxides, hetero
7. Diblock Copolymer, - Aviram (Review Article), Nature,

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| Credits | 4 |

| Course Category | Departmental Elective (II Semester) |

| Pre-requisite(s) | Basic Knowledge of Mathematics |

| Contact Hours (L-G-P) | 3-1-0 |

| Type of Course | Theory |

| Course Assessment | Home Assignments (including MATLAB based problems and Quizzes) (15%)  
Midsem Examination (1 hour) (25%)  
Endsem Examination (2 hours) (60%) |

### Course Outcomes (COs)

Nanosensors and Nanodevices

*After completion of this course, students shall be able to:*

1. understand the basic concept of nanosensor, biosensor and biochip
2. learn the characteristics and physical effects of nanosensor
3. probe and understand various biological sensors
4. learn and implement the knowledge in designing the nanosensor for various applications

### Syllabus

**UNIT 1: Micro and Nano-Sensors**

Fundamentals of sensors, biosensor, micro fluids, MEMS and NEMS

**UNIT 2: Packaging and Characterization of Sensors**

Method of packaging at zero level, dye level and first level.

**UNIT 3: Sensors**

Sensors for aerospace and defense: Accelerometer, Pressure Sensor, Night Vision System, Nano tweezers, nano-cutting tools, Integration of sensor with actuators and electronic circuitry, Sensor for bio-medical applications: Cardiology, Neurology and as diagnostic tool, For other civil applications: metrology, bridges etc.

**UNIT 4: Biosensors**

Clinical Diagnostics, generation of biosensors, immobilization, characteristics, applications, conducting Polymer based sensor, DNA Biosensors, optical sensors

**UNIT 5: Biochips**

Metal Insulator Semiconductor devices, molecular electronics, information storage, molecular switching, Schottky devices
UNIT 6: Quantum Structures and Devices

Books and References
2. Between Technology & Science : Exploring an emerging field knowledge flows & networking on the nanoscale by Martin S. Meyer.
3. Nanoscience & Technology: Novel structure and phenomea by Ping Sheng (Editor)
7. MEMS & MOEMS Technology and applications- P. RaiChoudhury
8. Processing Technologies- Gandhi
9. From Atom to Transistor- Supriyo Datta

Relationship of COs with Pos

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Course Number and Title: NTE-7200 Carbon nanotubes and its functionalization
Credits: 4
Course Category: Departmental Elective (II Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-G-P): 3-1-0
Type of Course: Theory
Course Assessment: Home Assignments (including MATLAB based problems and Quizzes) (15%), Midsem Examination (1 hour) (25%), Endsem Examination (2 hours) (60%)

Course Outcomes (COs)

Carbon nanotubes and its functionalization
After completion of this course, students shall be able to:
1. get comprehensive knowledge of carbon nanotubes, their properties and applications.
2. understand various methods of synthesis and characterisation of carbon nanotubes
3. understand the physics behind the unusual properties displayed by carbon nanotubes
4. understand the functionalization of carbon nanotubes with various inorganic functional groups

Syllabus
UNIT 1: Preparation of Carbon Nano-Tubes
CVD and other methods of preparation of CNT

UNIT 2: Properties of Carbon Nanotubes
Electrical, Optical, Mechanical, Vibrational properties etc.

UNIT 3: Applications of Carbon Nanotubes
Field emission, Fuel Cells, Display devices

UNIT 4: Functionalization of Carbon Nanotubes

UNIT 5: Other Important Carbon Based Materials
Preparation and Characterization Fullerene and other associated carbon clusters/molecules, Graphene-preparation, characterization and properties, DLC and nanodiamonds.
Books And References

1. Nanoscale materials - Liz Marzan and Kamat
2. Synthesis functionalization and surface treatment of nanoparticles - Marie Isabelle Baraton
3. Physical properties of Carbon Nanotube - R Satio
5. Carbon Nanotubes: Properties and applications - Michael J. O'Connell
6. CARBON NANOTECHNOLOGY - Liming Dai

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Course Number and Title: NTE-6210 Molecular Nanoelectronics
Credits: 4
Course Category: Departmental Elective (II Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-G-P): 3-1-0
Type of Course: Theory
Course Assessment:
- Home Assignments (including MATLAB based problems and Quizzes) (15%)
- Midsem Examination (1 hour) (25%)
- Endsem Examination (2 hours) (60%)

Course Outcomes (Cos)

Molecular Nanoelectronics
After completion of this course, students shall be able to:
1. get the basic knowledge of molecular nanoelectronics used in future electronic industry
2. have an idea of designing various nanoelectronic devices
3. get familiarize with theory and applications of spintronics

Syllabus

UNIT 1: Introduction:
Recent past, the present and its challenges, Future, Overview of basic Nanoelectronics:

UNIT 2: Molecular Electronics Components
Characterization of switches and complex molecular devices, polyphenylene based Molecular rectifying diode switches.
Technologies, Single Electron Devices, Quantum Mechanical Tunnel Devices, Quantum Dots & Quantum wires

UNIT 3: Nanoelectronic & Nanocomputer architectures and nanotechnology
Introduction to nanoelectronic and nanocomputers, Quantum DOT cellular Automata (QCA), Single electron circuits, molecular circuits Nanocomputer Architecture.

UNIT 4: Spintronics:
Introduction, Overview, History & Background, Generation of spin Polarization Theories of spin Injection, Spin relaxation and spin dephasing, Spintronic devices and applications, spin filters, spin transistors
Books and References:

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

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## Course Number and Title
NTE-6220 Optical properties of nanometrials, nanophotonics and plasmonics

## Credits
4

## Course Category
Departmental Elective (II Semester)

## Pre-requisite(s)
Basic Knowledge of Mathematics

## Contact Hours (L-G-P)
3-1-0

## Type of Course
Theory

## Course Assessment
- Home Assignments (including MATLAB based problems and Quizzes) (15%)
- Midsem Examination (1 hour) (25%)
- Endsem Examination (2 hours) (60%)

## Course Outcomes (Cos)

**Optical properties of nanometrials, nanophotonics and plasmonics**

*After completion of this course, students shall be able to:*

1. get the fundamental knowledge of the optical properties of nanomaterials
2. acquire clear cut understanding of how the optical properties of nanomaterials evolve with decreasing size
3. apply the above knowledge in nanophotonics and plasmonics

## Syllabus

### UNIT 1: Metal Nanoparticles
Metal Nanoparticles, Alloy Nanoparticles, Stabilization in Sol, Glass and other media, Change of bandgap, Blueshift, Colour change in Sol, glass and composites, Plasmon Resonance.

### UNIT 2: Physics of Linear Photonic Crystals

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

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

### UNIT 5: Physics of Nonlinear Photonics Crystals
Quasi Phase Matching, Nonlinear Photonic Crystal Analysis, applications of Nonlinear Photonic Crystals Devices, Materials: LiNbO3 Chalcogenide Glasses, etc, Wavelength Converters etc.
UNIT 6: Elements of Plasmonics

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

Books and References:

1. Springer Handbook of Nanotechnology by Bharat Bhushan
2. Encyclopedia of Nanotechnology- Hari Singh Malwa
3. The Handbook of Photonics By Mool Chand Gupta John Ballaoo
5. Nanoplasmonics, From fundamentals to applications Vol 1 & 2 – S. Kawata & H. Masuhara
6. Optical Properties of Photonic Crystals- K. Sakoda
7. applied Photonics by Chai Yeh
8. Silicon Photonics: An Introduction by Graham T. Reed, Andrew P. Knights.

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Course Number and Title : NTE-6230 Semiconductor nanostructures & nanoparticles
Credits : 4
Course Category : Departmental Elective (II Semester)
Pre-requisite(s) : Basic Knowledge of Mathematics
Contact Hours (L-G-P) : 3-1-0
Type of Course : Theory
Course Assessment : Home Assignments (including MATLAB based problems and Quizzes) (15%)
Midsem Examination (1 hour) (25%)
Endsem Examination (2 hours) (60%)

Course Outcomes (Cos)

NTE-6230 Semiconductor nanostructure & nanoparticles
After completion of this course, students shall be able to:
1. have the knowledge of semiconductors nanoparticles and their synthesis
2. design an application of these nanoparticles in LED and solar cells
3. learn the application strategies in semiconductor nanowires

Syllabus

UNIT 1 : Semiconductor nanoparticles Synthesis
Cluster compounds, quantum-dots from MBE and CVD, wet chemical methods, reverse micelles, electro-deposition, pyrolytic synthesis, self-assembly strategies.

UNIT 2: Semiconductor nanoparticles- size-dependant physical properties
Melting point, solid-state phase transformations, excitons, band-gap variations-quantum confinement, effect of strain on band-gap in epitaxial quantum dots, single particle conductance.

UNIT 3: Semiconductor nanoparticles – applications
Optical luminescence and fluorescence from direct band gap semiconductor nanoparticles, surface-trap passivation in core-shell nanoparticles, carrier injection, polymer-nanoparticle, LED and solar cells, electroluminescence, barriers to nanoparticle lasers, doping nanoparticles, Mn-Zn-Se phosphors, light emission from indirect semiconductors, light emission form Si nanodots.

UNIT 4: Semiconductor nanowires
Fabrication strategies, quantum conductance effects in semiconductor nanowires, porous Silicon, nanobelts, nanoribbons, nanosprings.
Books and References:
1. Encyclopedia of Nanotechnology- Hari Singh Nalwa
2. Springer Handbook of Nanotechnology - Bharat Bhusan
3. Handbook of Semiconductor Nanostructures and Nanodevices Vol 1-5- A. Balandin, K. L. Wang
4. Nanostructures and Nanomaterials - Synthesis, Properties and applications- Cao, Guozhong

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Course Number and Title: NTE-7240 MEMS and their applications  
Credits: 4  
Course Category: Departmental Elective (II Semester)  
Pre-requisite(s): Basic Knowledge of Mathematics  
Contact Hours (L-G-P): 3-1-0  
Type of Course: Theory  
Course Assessment:  
- Home Assignments (including MATLAB based problems and Quizzes) (15%)  
- Midsem Examination (1 hour) (25%)  
- Endsem Examination (2 hours) (60%)  

Course Outcomes (Cos)  
MEMS and their applications  
After completion of this course, students shall be able to:  
1. understand the concept of MEMS and its compatibility with microelectronics  
2. learn the techniques of material processing  
3. understand how to use these materials for sensing applications in high temperature and harsh environment  

Syllabus  
UNIT 1: MEMS (An Introduction)  
Tribology of MEMS, diaphragm, beams, cantilever; mems based devices, pressure sensors, capacitive sensors, actuators, transducers, accelerometers, inertial sensors, bio-sensors, optical sensors, rf switch, resonators, gas sensors, vacuum sealed cavity, absolute pressure sensors.  

UNIT 2: Materials And Processing (1)  
Single crystalline silicon. Microelectronic processes; chemical cleaning, oxidation, diffusion, ion-implantation pattern delineation, RIE, LPCVD, PECVD and INCCVD of silicon, SiO₂ and Si₃N₄, mask layout using l-edit and mask fabrication. Wet and dry etching processes; isotropic etching, anisotropic etching. Anisotropic etching of crystalline silicon in aqueous koh; effect of temperature and KOH concentration, etching of silicon in KOH near boiling point.  

UNIT 3: Materials And Processing (2)  
Micromachining; bulk, surface and front-side etching; convex and concave compensation. Back to front alignment; tools and processes. Thin film processes; e-beam evaporation, electro deposition, sputtering; rf, dc and magnetron. Polysilicon; sacrificial layer and piezo-resistive materials grain growth mechanism, doped polysilicon.  

UNIT 4: Processes and Tools  
Compatibility of MEMS with microelectronics; neutralisation of koh traces, process sequence optimization. Deep reactive ion etching (DRIE) and liga processes. Microfluidics. MEMS—
CAD tools; convertor, ansys, intellisuit, smart sensors, design methodology of polysilicon piezo resistive pressure sensor. Anodic bonding of silicon to glass. Packaging of sensor chips. Materials for sensing applications in high temperature and harsh environment. Kelvin probe.

Books And References


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Course Number and Title: NTE-7260 Nano-Entrepreneurship

Credits: 4
Course Category: Departmental Elective (II Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-G-P): 3-1-0
Type of Course: Theory
Course Assessment:
- Home Assignments (including MATLAB based problems and Quizzes) (15%)
- Midsem Examination (1 hour) (25%)
- Endsem Examination (2 hours) (60%)

Course Outcomes (Cos)

Nano-Entrepreneurship
After completion of this course, students shall be able to:
1. explain the general working structure and different issues involved in various industries
2. understand the Indian business laws
3. acquire knowledge of nanotechnology entrepreneurship

Syllabus

UNIT 1: Proprietorships, Partnerships, and Companies
Proprietorship versus Partnership versus Cooperative versus Private Limited Company versus Public Limited Company. Relative advantages and disadvantages Partnership Act; Franchising; Industrial cooperatives; Funding sources for small and medium scale sectors; Angel Investors; Venture Capital; Limited Liability Partnership; Salient features of the Companies Act as amended up to date; Proposed amendments to the Companies Act; Independent Directors; Shares; Initial Public Offer; Stock Market; Online stock trading

UNIT 2: Other Business Considerations
Import Scenario in India; Contract Law; Advertising; Marketing; Consumer Protection Act; E-Commerce; Dealing with banks; Negotiable Instruments; Different types of Accounting and their advantages and disadvantages; Annual Reports; Sales Tax; Service Tax; Patents, Designs, Trade Marks, Copyrights, etc.; Business Insurance; Insolvency; Arbitration; Labour welfare; Special Economic Zones; Manufacturing Investment Regions; Corporate Social Responsibility; Comparison of Indian business laws with the business laws of other countries; Areas of reforms needed in Indian business laws

UNIT 3: Business of Nano Technologies
Co’hImerCialiy available nanotechnology products and products likely to be commercialized in future; Survey of nanotechnology companies in the world, in India and in Delhi and Aligarh areas; Proposed mega-size nanotechnology projects in Andhra Pradesh, Haryana and Karnataka; Ace Nanotech Pvt Ltd, Ace Nanocepts Technologies Pvt. Ltd., I Cube Nanotech India Pvt. Ltd, Nano Works Developers Pvt Ltd, Nanobiosym Technologies India Pvt.
Ltd, Nano Electrotech Pvt Ltd, Om Nanotech Pvt Ltd, Vrinda Nano Technologies Pvt Ltd, Facilitatory efforts for such companies by the Central and State Governments and by major business bodies in India; ASSOCHAM Nanotech Governing Council; CII Nanotechnology Initiative; Nano Science & Technology Consortium; Nanotechnology Business Group; Business models for Rs. 1-10 lakh, Rs. 10 lakh-1 crore, Rs 1-10 crore, Rs 10-100 crore, above Rs 100 crore. Need for Nanotechnology Act.

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**Course Outcomes (Cos)**

**Graphene and its applications**

After completion of this course, students shall be able to:

1. learn the methods of synthesis & characterisation of graphene and graphene oxide
2. understand the physics behind the unusual properties displayed by graphene
3. understand its application in graphene transistors, transparent conducting electrodes, photo detectors, light emitting diodes, photo voltaics, graphene sensors etc.

**Syllabus**

**UNIT 1: Synthesis and Characterization**

Mechanical exfoliation, Liquid phase exfoliation, Thermal decomposition of SIC, Chemical Vapour deposition, Molecular beam epitaxy and other methods. Raman Spectroscopy, Optical Microscopy and Electron Microscopy, Band gap determination by ARPES

**UNIT 2: Crystal and Band structure**

Sp2 hybridisation in carbon atom, graphitic allotropes, crystal structure of graphene, chirality, tight binding model for electrons on the honeycomb lattice, solution for graphene with next nearest neighbour interaction, energy dispersion in the continuum limit.

**UNIT 3: Dirac equation for Graphene and its consequences**

Dirac equation in 3 and 2 dimensions, Eigen states of the 2D Dirac Hamiltonian, Symmetries and Lorentz transformation, Klein tunnelling

**UNIT 4: Properties and applications**

Electronic transport and field effect, Magneto resistance and quantum Hall effect, Weak localization and antilocalization, Optical, Mechanical, Vibrational properties etc
Graphene transistors, Transparent conducting electrodes, Photo detectors, Light emitting diodes, Photovoltaics, Graphene sensors
REFERENCES-

A. Books:

B. Review Articles

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Course Number and Title: NTC-6900 Lab I

Credits: 2
Course Category: Departmental Core (I Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-G-P): 0-1-2
Type of Course: Practical
Course Assessment: Course Work (60%)
Endsem Examination (2 hours) (40%)

Course Outcomes (Cos)

NTC-6900 Lab I
After completion of this course, students shall be able to:
1. learn different tools of experimental setup like Four probe resistivity, Hall Effect, FTIR, etc.
2. use these tools to enhance the knowledge for understanding nanomaterials in a fascinating way.
3. present the performed experiment in form of reports

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**Course Number and Title**: NTC-6910 Lab II

- **Credits**: 2
- **Course Category**: Departmental Core (II Semester)
- **Pre-requisite(s)**: Basic Knowledge of Mathematics
- **Contact Hours (L-G-P)**: 0-1-2
- **Type of Course**: Practical

**Course Assessment**: Course Work (60%)  
Endsem Examination (2 hours) (40%)

**Course Outcomes (Cos)**

**NTC-6910 Lab II**

*After completion of this course, students shall be able to:*

1. learn different tools of experimental setup like Resistivity by two probe method, Frequency dependence of dielectric, Curie temperature of BaTiO$_3$, etc.
2. use these tools to enhance the knowledge for understanding nanomaterials in a fascinating way.
3. present the performed experiment in form of reports

**Relationship of COs with Pos**

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# M.Tech Curriculum (Nanotechnology)

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<th>Course No.</th>
<th>Course Title</th>
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**Total Credit**: 21

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**Total Credit**: 11

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**Total Credit**: 18

**Total M. Tech Credit**: 72
### List of Possible Electives (Nanotechnology)

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### List of Open Electives (Nanotechnology)

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