DEPARTMENT OF APPLIED PHYSICS, Z. H. COLLEGE OF ENGG. & TECH.
A.M.U., ALIGARH

Minutes of an ordinary meeting of the Board of Studies of the Department of Applied Physics, Z. H.
College of Engg. & Tech., A.M.U., Aligarh held on 08.07.2017 at 1:00 p.m. in the Staff Room of the
Department.

Following members were present:
1. Prof. Ameer Azam (In the Chair)
2. Prof. Hafizur Rahman
3. Prof. Shakeel Khan
4. Dr. Azra Parveen
5. Dr. Pushpendar Tripathi
6. Dr. S. Asad Ali
7. Dr. Zafrul Hasan

Before taking up the agenda, Prof. Ameer Azam, welcomed the members of BOS.

Following decisions were taken:

1. Confirmed the minutes of the last BOS held on 25.05.2017.
2. Approved the Vision & Mission of the Department, Programme Educational Objectives (PEOs),
   Programme Outcomes (POs) and Course Outcomes (COs) of M.Tech. Nanotechnology Programme. [Appendix –I].

   The meeting then came to an end with vote of thanks by the Chairperson.

(Prof. Ameer Azam)
Chairperson

[Signature]
04.10.17
Vision of Applied Physics Department

The vision of the Department of Applied Physics is to be the leading department in interdisciplinary education and research in the region and to be recognized internationally as a leader in the field of Nanoscience and Nanotechnology.

Mission of the Department

The mission of the Department of Applied Physics is to promote excellence and innovation in teaching and research in interdisciplinary area “development of novel materials” for the benefit of mankind.

In order to accomplish the stated mission, the Department will:

• Advance the frontiers of knowledge and role of Aligarh Muslim University through quality teaching of basic and interdisciplinary science at Under Graduate & Post Graduate levels and indulge in extensive innovative product development oriented Applied Physics research.
• Design and revise curricula on a regular basis so as to provide effective use of Physics in real-time engineering problems.
• Educate and train young engineers and researches to stand to fulfill university, government, societal and industrial needs.
• Accelerate transfer of knowledge and provide testing and consulting services to industry in order to improve quality of research.
• Disseminate knowledge by organizing workshops, seminars and conferences.
• Attract and generate support funds which are critical to the long term sustainment of the education and research (ER) program.
Program Educational Objectives (PEOs):

PEO-1: To prepare students with sound theoretical and experimental knowledge in the multidisciplinary field of nanotechnology.

PEO-2: To inculcate state-of-the-art skills in the students for producing various nanomaterials useful for energy, environment, medicine, agriculture, defense etc.

PEO-3: To encourage students to pursue research in this field and/or become entrepreneurs.

Program Outcomes (POs)

a. Ability to apply knowledge of Physics, Chemistry and Mathematics to formulate and analyze nanotechnological problems and to develop nanomaterials.
b. Ability to design and solve problems related to the needs of the society.
c. Ability to use modern tools and techniques for solving the problems in emerging areas.
d. Ability to identify and solve research problems in core and related multidisciplinary areas for rapidly changing technologically advancing society.
e. Ability to develop effective written and oral communication skills.
f. Ability to understand the ethical, professional and societal responsibilities.
g. Ability to manage nanotechnological projects and problems effectively under practical and environmental constraints.
h. Ability of independent thinking and lifelong learning.
Course Number and Title: INC-610 Fundamentals of Nanotechnology
Credits: 4
Course Category: Departmental Core (I Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-T-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
Process of Self-Assembly, Semiconductor Islands, Monolayers, nature of Catalysis, Surface Area of Nanoparticles, Porous Materials, Pillared Clays, Colloids

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

UNIT 4: Quantum Wells, Wires and Dots
Introduction, Size and Dimensionality Effects, Size Effects, Conduction Electrons and Dimensionality, Fermi gas and Density of States, Potential Wells, Partial Confinement, Properties dependent on Density of States, Exitons
UNIT 5: Nanotechnology in Carbon Materials
Fullerenes and Carbon Nanotubes, Fullerenes as nano-structures, structures of C\textsubscript{60}, C\textsubscript{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 : INC-611 Quantum Mechanics  
Credits : 4  
Course Category : Departmental Core (I Semester)  
Pre-requisite(s) : Basic Knowledge of Mathematics  
Contact Hours (L-T-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: INC-612 PHYSICS AND CHEMISTRY OF SOLIDS
Credits: 4
Course Category: Departmental Core (I Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-T-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: Mettalic, 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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### Course Number and Title

INC-613 *Elements of Physical Chemistry*

### Credits

4

### Course Category

Departmental Core (I Semester)

### Pre-requisite(s)

Basic Knowledge of Mathematics

### Contact Hours (L-T-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 Number and Title: INC-614 Synthesis and characterization of Nanomaterials

Credits: 4
Course Category: Departmental Core (I Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-T-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 /synthesise 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 : INC-615 Nanobiotechnology
Credits : 4
Course Category : Departmental Core (II Semester)
Pre-requisite(s) : Basic Knowledge of Mathematics
Contact Hours (L-T-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)

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: Microorganisms 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. Nanosystems: Molecular Machinery, Manufacturing, and Computation - K. Eric Drexler
9. Springer Handbook of Nanotechnology - Bharat Bhushan

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**Course Number and Title**: INC-616 Properties of Nanomaterials

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**Course Outcomes (COs)**

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**: INC-617 Nanocomposite  
**Credits**: 4  
**Course Category**: Departmental Core (II Semester)  
**Pre-requisite(s)**: Basic Knowledge of Mathematics  
**Contact Hours (L-T-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)**

**INC-617 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 Veprējek (Review Article) JVST A, 1999
5. Electromagnetic and magnetic properties of multi component metal oxides, hetero
7. Diblock Copolymer, - Aviram (Review Article), Nature,

Relationship of COs with POS

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</table>
Course Number and Title: INC-719 Nanosensors and Nanodevices  
Credits: 4  
Course Category: Departmental Core (III Semester)  
Pre-requisite(s): Basic Knowledge of Mathematics  
Contact Hours (L-T-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 phenomena by Ping Sheng (Editor)
7. MEMS & MOEMS Technology and applications - P. RaiChoudhury
8. Processing Technologies - Gandhi
9. From Atom to Transistor - Supriyo Datta

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</table>
Course Number and Title: INC-720 Carbon nanotubes and its functionalization
Credits: 4
Course Category: Departmental Core (III Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-T-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: INC-721 Molecular Nanoelectronics
Credits: 4
Course Category: Departmental Core (III Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-T-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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</table>
Course Number and Title : INC-722 Optical properties of nanomaterials, nanophotonics and plasmonics
Credits : 4
Course Category : Departmental Core (III Semester)
Pre-requisite(s) : Basic Knowledge of Mathematics
Contact Hours (L-T-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 nanomaterials, 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
1-D 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: INC-723 Semiconductor nanostructure & nanoparticles
Credits: 4
Course Category: Departmental Core (III Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-T-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)

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 Bhushan
3. Handbook of Semiconductor Nanostructures and Nanodevices Vol 1-5 - A. A. Balandin, K. L. Wang
4. Nanostructures and Nanomaterials - Synthesis, Properties and applications - Cao, Guozhong

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Course Number and Title: INC-724 MEMS and their applications
Credits: 4
Course Category: Departmental Core (III Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-T-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; conventor, 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: INC-726 Nanoentrepreneurship
Credits: 4
Course Category: Departmental Core (III Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-T-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)

Nanoentrepreneurship
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
Commercially 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 Number and Title: INC-727 Graphene and its applications
Credits: 4
Course Category: Departmental Core (III Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-T-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)

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

Relationship of COs with POS

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Course Number and Title : INC-690 Lab I

Credits : 4
Course Category : Departmental Core (III Semester)
Pre-requisite(s) : Basic Knowledge of Mathematics
Contact Hours (L-T-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)

INC-690 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

List of Experiments

[1]. To analyse the given Solid Material (TiO$_2$) using FTIR Spectrophotometer and analyse the data using Origin Software.
[2]. Chemical Synthesis of Silver Nanoparticles (AgNP's) in Aqueous Solvent.
[3]. To Synthesize Gold Nanoparticles (AuNP's) using Chemical Method.
[4]. Biological Synthesis of Silver Nanoparticles (AgNP's) using Plant Extract.
[5]. Method for Preparation of Biological media for Bacterial growth.
[6]. To measure Fluorescence property of TiO$_2$ Nanoparticles.
[7]. To determine the concepts of Adhesion & Wetting by measuring the Contact angle of Liquid on a glass Substrate.
[8]. To determine the Miller indices & Crystalline Size of given Nanoparticles using X-ray diffraction Techniques and to analyse the XRD data using (Powder X) Software.
[9]. To study variation of resistivity of a semiconductor with temperature by four probe method and evaluate energy band gap of the material.
[11]. To find out the Surface Plasmon Resonance of given Nanoparticles using UV-Vis Spectrophotometer and determine the energy band gap with the help of Tauc relation.
[12]. To study variation of Dielectric Constant with frequency by using LCR meter.
### Relationship of COs with Pos

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Course Number and Title : INC-691 Lab II

Credits : 4
Course Category : Departmental Core (III Semester)
Pre-requisite(s) : Basic Knowledge of Mathematics
Contact Hours (L-T-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)

INC-691 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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Course Number and Title : INC-790 Lab III

Credits : 4
Course Category : Departmental Core (III Semester)
Pre-requisite(s) : Basic Knowledge of Mathematics
Contact Hours (L-T-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)

INC-790 Lab III

After completion of this course, students shall be able to:
1. learn synthesis and characterization techniques to prepare nanomaterials
2. apply the knowledge and skills gained to solve nanotechnological problems
3. present the performed experiment in form of reports.

List of Experiments

[1]. Chemical synthesis of Nickel nanoparticles at room temperature.
[2]. Chemical synthesis of TiO₂ nanoparticles and its characterization using UV-Vis, FTIR, Photoluminescence & Contact measurement angle.
[4]. Fungus mediated biosynthesis of metal nanoparticles.
[5]. To Study the antibacterial property of silver nanoparticles using Disc Diffusion Method.
[6]. To synthesize the multiferroic (BaTiO₃) nanoparticles by Sol-gel method.
[7]. Synthesis of Quantum dots (CdS) & analyse its band gap by using Fluorescence Spectroscopy.

Relationship of COs with Pos

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Course Number and Title: INC-798N Project Dissertation

Credits: 4
Course Category: Departmental Core (Semester)
Pre-requisite(s): Basic Knowledge of Mathematics
Contact Hours (L-T-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)

INC-798N Project Dissertation

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

1. effectively present the solution of the identified problem
2. draw inferences on the basis of findings
3. defend the findings by effective presentation

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