MEPCO SCHLENK ENGINEERING COLLEGE, SIVAKASI
(AUTONOMOUS)
AFFILIATED TO ANNA UNIVERSITY, CHENNAI 600 025
REGULATIONS: MEPCO - R2013 (FULL TIME)

M.TECH NANO SCIENCE AND TECHNOLOGY (FULL TIME)

<table>
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<th>Department Vision</th>
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<td>Rendering services to the global needs of engineering industries by educating students to become professional mechanical engineers of excellent calibre</td>
<td>To produce mechanical engineering technocrats with a perfect knowledge of intellectual and hands on experiences and to inculcate the spirit of moral values and ethics to serve the society</td>
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**Programme Educational Objectives (PEOs)**

**Basic Understanding**
To provide the basic scientific, engineering knowledge and practical knowledge to become a skilled practicing nano technologist.

**Breadth**
To become full-fledged technocrats, applying technical skills in the synthesis, analysis and developing nano products for the real life concerns.

**Adaptive Learning**
To engage in sustained learning for career research opportunities in academics, entrepreneurial endeavours and industries for ever-changing technological requirements.

**Competency**
To have competency in research excellence to pursue higher studies and to become eminent technocrats.
Programme Outcomes (POs)

1. Emphasising the fundamentals in the general principles of physics, chemistry, materials, electronics and biology.
2. Insight into the materials, fabrication and other experimental techniques used in the nano scale.
3. Understanding the formation of complex nano systems to design new functional products.
4. In-depth knowledge in the field of nano science and technology.
5. Expertise in latest nano engineering tools with advanced software knowledge.
6. Implementing latest nano technological advancements for the benefit of society.
7. Nanotech solutions to green and sustainable development.
8. Realizing professional ethics in technical field.
9. Perform individual activity/leadership ability in a multifaceted research group.
10. Communication competency in presenting/publishing research reports.
11. Capability in completing a task within financial constraint.
12. Updating the current nano technological developments.

I SEMESTER

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# M.TECH NANO SCIENCE AND TECHNOLOGY (PART TIME)

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<td>Nanoparticles and Microorganisms, Bio Nano Composites</td>
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I SEMESTER
13MA176: MATHEMATICAL MODELING AND SIMULATION

COURSE OBJECTIVES:

- To introduce the fundamental principles of numerical methods.
- To provide various methods of solving system of simultaneous equations.
- To know about mathematical modeling.
- To have thorough knowledge about differential equations.
- To familiarize in simulation and monte-carlo methods.

COURSE OUTCOMES:

Upon completion of the course the students will be able

- To solve problems using numerical methods.
- To obtain the solution of system of equations using matrix theory.
- To model the real life problems into mathematical problems.
- To identify the various types of differential equations and methods for finding solutions.
- To apply the simulation techniques in their field.

UNIT I  FUNDAMENTAL PRINCIPLES OF NUMERICAL METHODS

UNIT II  MATRICES AND LINEAR SYSTEMS OF EQUATIONS  12


UNIT III  MATHEMATICAL MODELING  12


UNIT IV  DIFFERENTIAL EQUATIONS & APPLICATIONS  12


UNIT V  SIMULATION & MONTE CARLO METHODS  12

Basic concepts of simulation - data manipulation, data exchange of the structure, physical simulation - advantages and limitations - properties and processing of materials - basics of the monte carlo method – algorithms for monte carlo simulation - molecular dynamics simulation - applications to systems of classical particles - modified Monte Carlo
techniques - percolation system – variation Monte Carlo method.

TOTAL: 60 PERIODS

REFERENCE BOOKS:


13NT101 : QUANTUM MECHANICS

COURSE OBJECTIVES:

- To impart basic knowledge about the quantum concepts.
- To become aware of the necessity for quantum methods in the analysis of physical systems of atomic and solid state physics.
- To understand the various parameters like linear and Hermitian operator.
- To improve mathematical skills necessary to solve differential equations and eigen value problems.
To explain scientifically the new applications of quantum physics in computation.

**COURSE OUTCOMES:**

- Conceptual understanding of the basic principles of quantum mechanics.
- Ability to apply basic principles of the wave quantum mechanics towards solutions of various problems.
- Capability to apply basic operator methods towards solutions of various problems.
- Conceptual and practical understanding of the following subjects of 1) quantum particle trapped in various potential wells 2) Quantum simple harmonic oscillator 3) Simple quantum model of the hydrogen atom.
- Experience in computer simulation and modeling.

**UNIT I  INTRODUCTION**

Inadequate of classical mechanics–Blackbody radiation - Compton Effect - Photoelectric effect – Planck’s quantum concepts – Correspondence principle - Wave-particle duality - Schrödinger equation and expectation values - Uncertainty principle.

**UNIT II  BASICS OF QUANTUM MECHANICS**

UNIT III OPERATORS AND COMPUTATIONAL LAWS 9

UNIT IV APPROXIMATE METHODS 9
Time independent and time dependent perturbation theory for non-degenerate and degenerate energy levels - Variation method - WKB approximation - adiabatic approximation - sudden approximation.

UNIT V QUANTUM COMPUTATION 9

TOTAL: 45 PERIODS

REFERENCE BOOKS:


COURSE OBJECTIVES:

- To understand the evolution of nano science and basic concepts of nano materials.
- To acquire knowledge about theories behind the interaction of nanoparticles.
- To understand the chemistry of nano materials for various applications.
- To understand the exotic properties of nanostructured materials at nano scale lengths.
- To acquire knowledge about the bottom-up synthesis of various nanoparticles.

COURSE OUTCOMES:

- Gain knowledge on basic science behind nanotechnology.
- Capable of interpreting the nano scale phenomena of particles.
- Ability to diagnose and use the exact nanomaterial for needed applications.
- Acquire knowledge about the various properties of nano materials.
- Able to synthesis and manipulate nanoparticles by bottom-up approach.
UNIT I  INTRODUCTION, CLASSIFICATION AND NOMENCLATURE OF NANO MATERIALS

Background to nano technology - Scientific revolutions - Basic principles of nano scale materials- Nano sized metals and alloys, semiconductors, ceramics. Comparison with respective bulk materials; Organic semiconductors, carbon nanotubes; Zero, one, two, and three dimensional nanostructures – quantum dots, quantum wells, quantum rods, quantum wires, Nano composites consisting of organic, inorganic and biomaterials; Self-assembly.

UNIT II  THEORIES OF NANO SIZED MATERIALS

Transition metal sols, origin of plasmon band, Mie theory, influence of various factors on the plasmon absorption; Surface energy – chemical potential as a function of surface curvature - electrostatic stabilization - surface charge density - electric potential at the proximity of solid surface - Zeta potential - Interaction between two particles: DLVO theory.

UNIT III  CHEMISTRY ASPECTS OF NANOMATERIALS

Photochemistry - Electrochemistry of Nanomaterials - Nanoscale heat transfer - Catalysis by gold nanoparticles - Transport in semiconductor nanostructures - Transition metal atoms on nano carbon surfaces - Nano deposition of soft materials.

UNIT IV  NOVEL PROPERTIES OF NANOMATERIALS

surface area and aspect ratio - Size and shape dependent optical, emission, electronic, transport, photonic, refractive index, dielectric, mechanical, magnetic, non-linear optical properties; Catalytic and photo catalytic properties.

UNIT V  NANOSYSTEMS

Nanoparticles through homogeneous and heterogeneous nucleation - Growth controlled by surface and diffusion process - Oswald ripening process - influences of reduction reagents - solid state phase
segregation.

TOTAL: 45 PERIODS

REFERENCE BOOKS:


WEB REFERENCE:

1.“Encyclopedia of nano science and nanotechnology”, Vol.1,2,6,7,10.
COURSE OBJECTIVES:

- To kindle the knowledge about a unique nano material like carbon nano tube, occurrence, invention etc.
- To gain idea about the synthesis of CNT by various methods.
- To provide knowledge about the functionalization of CNT.
- To apply CNT for different applications.
- To provide information about graphene, diamond like thin films.

COURSE OUTCOMES:

- Emphasizes the significance of carbon nano materials and its applications.
- Gives idea about the entire properties of CNT and its preparation techniques.
- To suit for advanced applications, functionalization of CNT.
- Imparts about the applications of CNT in almost all fields.
- Knowledge about Graphene, Graphene oxide, Diamond like films.

UNIT I CARBON NANOTUBES: STRUCTURE AND PROPERTIES

UNIT II  PREPARATION OF CARBON NANOTUBES  9


UNIT III  FUNCTIONALIZATION OF CARBON NANOTUBES  9


UNIT IV  APPLICATIONS OF CARBON NANOTUBES  9


UNIT V  OTHER IMPORTANT CARBON BASED MATERIALS  9

Preparation and characterization fullerene and other associated carbon clusters/molecules – Graphene - preparation - characterization and properties - DLC and nano diamonds.

REFERENCE BOOKS:


13NT104 : FABRICATION OF NANOMATERIALS   L   T   P   C
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COURSE OBJECTIVES:

- To understand the vacuum technique for the purpose of fabricating/imaging of nano materials.
- To educate the chemical, physical approaches for the fabrication of nano materials.
- To envisage the bulk synthesis methods for nano materials.
- To learn the concept and classification of lithography.
- To study and analyse the nano porous materials and its applications.

COURSE OUTCOMES:

- Understand the concept of vacuum system.
- Prominence the methods used for the fabrication of nano materials.
- Gain knowledge on bulk synthesis of nano materials.
- Recognize the importance of nano porous materials.
- Cultivate the concept of lithography.

UNIT I     VACUUM TECHNIQUE

Inert gas condensation technique – vacuum production - ion pumps –

UNIT II BULK SYNTHESIS

High energy ball mill – types of balls – ball ratio – medium for grinding – limitations – severe plastic deformation – Mechano chemical process – Arc plasma - Bulk and nano composite materials.

UNIT III CHEMICAL APPROACHES

Sol gel processing - Solvo thermal, hydrothermal, precipitation, Spray pyrolysis - Electro spraying and spin coating - Self-assembly, self-assembled monolayers (SAMs) - Langmuir-Blodgett (LB) films - microemulsion polymerization - templated synthesis, pulsed electrochemical deposition.

UNIT IV PHYSICAL APPROACHES

Vapour deposition and different types of epitaxial growth techniques (CVD, MOCVD, MBE) - Pulsed laser deposition, Magnetron sputtering - Lithography: Photo/UV/EB/FIB techniques, Dip pen nanolithography - Etching process: Dry and wet etching - micro contact printing.

UNIT V NANOPOROUS MATERIALS


TOTAL: 45 PERIODS

REFERENCE BOOKS:


13NT105: BASIC BIOLOGICAL SCIENCES

COURSE OBJECTIVES:

- To understand the various organelles of the cell and their function.
- To learn the basic cellular processes like replication, transcription and translation.
- To understand the importance of amino acids and proteins.
- To understand the structure and significance of carbohydrates and lipids.
- To develop a knowledge about the cells energy production pathways.

COURSE OUTCOMES:

- Able to differentiate cellular components.
• Understand how the central dogma of life works out.
• Describe the structure and function of various biomolecules.
• Able to understand the importance of biomolecules and their role in various cellular metabolic activities.
• Able to understand the energetics of the cell.

UNIT I CELL BIOLOGY


UNIT II NUCLEIC ACIDS

Introduction to DNA structure: Composition - nucleotide structures, double helix, genome structure and organization of Prokaryotes and Eukaryotes, Central dogma of life, DNA is the genetic material: Griffith, avery and hershey experiments, DNA replication: Semi-conservative mode of replication, experiment, enzymology, inhibitors, Transcription: Enzymology, Transcription factors, inhibitors, Translation: genetic code, enzymology, translational factors and inhibitors.

UNIT III AMINO ACIDS AND PROTEINS

Amino acids: Introduction, structure, classification, physical, chemical and optical properties, peptide bond, Proteins: Structure - Primary, secondary, super secondary, Tertiary and quaternary structures, Covalent and non-covalent interactions in protein structure, Classification, Enzymes- Introduction to structure, properties.

UNIT IV CARBOHYDRATES AND LIPIDS

Structure, Nomenclature, Function and classification of carbohydrates, mono, di and polysaccharides and Lipids- saturated and unsaturated fatty acids.
UNIT V    METABOLISM AND ENERGY PRODUCTION


TOTAL: 45 PERIODS

REFERENCE BOOKS:


13NT151 : MATERIAL SYNTHESIS  

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COURSE OBJECTIVES:

- To give hands on training about the synthesis of nano particles.
- To provide various methods for obtaining different categories of nano particles.
- To provide knowledge about the characterization of materials.

58
• To evaluate the band gap of semi conducting nano particles.
• To familiarize about various equipment and its operating procedures.

COURSE OUTCOMES:

• Able to follow different synthetic strategies adopted for isolating nano particles.
• Have acquired knowledge in background principles about the formation of nano materials.
• Understand the particle size evaluation, crystallite size determination etc.
• Knows about the characteristics of band gap of semi conducting particles.
• Getting trained in isolation of any kind of nano materials.

LIST OF EXPERIMENTS:

1. Aqueous to organic phase transfer of Ag and Cds nanoparticles; Confirmation by UV-Visible absorption.
3. Mechanical ball milling technique to oxide ceramics preparation: Crystallite size measurement by XRD.
4. Bio leaf extraction route to Ag/Cu/Fe nanoparticles.
5. Electro spinning of polymer nano fibers: Surface morphology by SEM.
7. Synthesis of aqueous ferro fluid by chemical method.
8. Nano crystalline copper metallic powder by polyol method.
COURSE OBJECTIVES:

- To provide an introduction to Molecular modeling & simulation.
- To understand the principles and techniques involved in offline image processing and image enhancements.
- To study the Single-Electron Transistor (SET) device and process simulation.
- Provide hands-on experience in simulation software packages like MATLAB, SIMULINK, MATERIALS STUDIO, XEI, TCAD, SEQUEL and MOSES 1.2 simulator.

COURSE OUTCOMES:

After studying this course students would be able to:

- Understand the concept of Molecular modeling & simulation.
- Recognize the significance of computational modeling and simulation.
- Solve I-V characteristics for a single junction circuit using Circuit simulator.
- Emphasis on materials digital image processing and image enhancement.
- Incorporate Modeling and simulation knowledge for solving a real scientific problem using software packages.

LIST OF EXPERIMENTS:

1. MATLAB programme to plot the first four Eigen functions of a one-dimensional rectangular potential well with infinite potential barrier.
2. Numerical solution of the Schrodinger wave equation for a rectangular potential well with infinite potential barrier using
MATLAB programme.

3. To model in molecular electronics: I-V characteristics of a single level molecule.

4. To determine the lattice constant and lattice angles for atomically resolved STM image of HOPG (Highly Oriented Pyrolytic Graphite using offline Scanning Probe Imaging Processor (SPIP) Software.

5. To determine the surface roughness of raw and processed AFM images of glass, silicon and films made by different methods using offline SPIP software.


7. Study of Single Electron Transistor using MOSES1.2 Simulator.


II SEMESTER
13NT201 : PHOTONICS FOR NANOTECHNOLOGY

COURSE OBJECTIVES:
The course should enable the students to

- Learn about quantum confinement of materials.
- Learn about near field optics.
- Know plasmonics.
- Understand photonics in the field of biology.
- Know concepts of photonics.

COURSE OUTCOMES:
The students will be able to

- Describe the effects of quantization on the optical properties of semiconductors and metals.
- Know principles of surface plasmon resonance and meta materials.
- Understand fundamentals of near field optics and its applications.
- Learn interactions of light with biological systems.
- Know important features of photonic crystals and applications.

UNIT I QUANTUM CONFINED MATERIALS 9


UNIT II PLASMONICS 9

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   NEW APPROACHES IN NANO PHOTONICS

Near-Field Optics - Aperture near-field optics - Aperture less 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   BIOPHOTONICS

Interaction of light with cells – tissues - nonlinear optical processes with intense laser beams - photo induced 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   PHOTONIC CRYSTALS

Important features of photonic crystals - Presence of photonic band gap - Anomalous group velocity dispersion - Micro cavity - 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.

TOTAL: 45 PERIODS

REFERENCE BOOKS:


13NT202 : PROCESSING AND PROPERTIES OF NANOSTRUCTURED MATERIALS

COURSE OBJECTIVES:

- To understand the metal forming methods and its deformation mechanisms.
- To gain knowledge about the microstructural properties of materials.
- To understand the processing methods of polymers.
- To understand the processing methods of metals and ceramics.
- To acquire knowledge about functional nano materials and its processing techniques.

COURSE OUTCOMES:

- Able to differentiate various metal forming methods.
- Acquire knowledge on the microstructural properties of materials.
- Ability to process the polymeric materials.
- Capable of processing metals and ceramics.
- Understand the mechanism to retain nanostructure during synthesis.
UNIT I DEFORMATION PROCESSING AND METAL FORMING


UNIT II MICROSTRUCTURE AND PROPERTIES

Defects in solids – classifications of defects – Microstructure – grain size, grain boundary, effects of processing and defects – Processing, microstructure, properties correlations – Mechanical Properties and processing - grain size evolution and grain size control; Hall - Petch relation - strengthening mechanisms; work hardening - grain boundary strengthening - solid solution strengthening – precipitation hardening - effects of diffusion on strength and flow of materials.

UNIT III PROCESSING OF POLYMERS

Engineering plastics – Pellets and sheets – Glass transition temperature of polymers – Melt flow index – Polymer processing tools and process conditions - injection moulding, thermoforming, vacuum and pressure assisted forming.

UNIT IV PROCESSING OF POWDERS OF METALS AND CERAMICS

Metal/Ceramic Powder synthesis - Selection and characterization of powders - compacting and sintering - Production of porous and dense composite components: Advanced composite materials – Metal - polymer and ceramic based composites and their properties – Fabrication of composite materials.
UNIT V  PROCESSING OF STRUCTURAL AND FUNCTIONAL NANOMATERIALS

Properties required of nano crystalline materials used for structural, energy, environmental, textile and catalytic applications - processing techniques - techniques for retaining nano crystalline structure in service.

TOTAL: 45 PERIODS

REFERENCE BOOKS:


WEB REFERENCE:


COURSE OBJECTIVES:

As a nano technologist, the student should have the knowledge in characterization of nano material in various aspects
• To understand the fundamentals regarding the analysis and interpretation of XRD data.
• To understand about thermal properties like thermal stability, thermal degradation etc.,
• Elucidation of structural features, molecular properties etc., will be gained by understanding knowledge based on spectroscopic techniques.
• To know about the applications of spectroscopy.
• To inculcate the mechanical properties of nano films by understanding nano indentation.

COURSE OUTCOMES:

• Able to analyse, interpret X-ray diffraction data of nano materials.
• It provide information about the thermal behaviours of nano materials.
• Understanding the concepts of spectroscopy towards elucidating structural aspects of nano materials.
• Capable to understand the molecular properties of nano material by spectroscopy.
• Able to comprehend the principles of nano indentation towards evaluating mechanical properties.

UNIT I SPECTROSCOPIC TECHNIQUES

Introduction to molecular spectroscopy and differences with atomic spectroscopy - UV-Vis. spectroscopy and applications to nano system (silver and gold ) – Infrared (IR) Spectroscopy and applications to metal oxide and chalcogenides – Raman Spectroscopy, applications to CNT and graphene – NMR Spectroscopy – Theory, principles, applications to simple molecules - Nuclear magnetic double resonance; Dynamic light scattering (DLS), ESR spectroscopy.
UNIT II  X-RAY DIFFRACTION  9

X-ray powder diffraction – Debye Scherer camera - Determination of accurate lattice parameters - line profile analysis - particle size analysis using Scherer formula - Impedance measurement, Electrical transport measurement (AC and DC conductivity, Magnetic transport properties characterization, Vibrating sample magnetometer (Hysteresis loop for soft and hard magnetic materials).

UNIT III  THERMAL ANALYSIS METHODS  9

Principle and Instrumentation of thermo gravimetry; Differential thermal analysis and Differential scanning calorimetry - Importance of thermal analysis for nanostructures - Atomic absorption spectroscopy, Inductively coupled plasma spectrometry.

UNIT IV  QUALITATIVE AND QUANTITATIVE ANALYSIS  9


UNIT V  NANOINDENTATION  9


TOTAL: 45 PERIODS

REFERENCE BOOKS:

2. M. H.Loretto, “Electron beam analysis of materials”, Chapman and
Hall, 1984.


13NT204 : ADVANCED IMAGING TECHNIQUES       L     T   P   C
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COURSE OBJECTIVES:

- To understand the concept of imaging techniques used for the purpose of characterizing the materials.
- To educate the different specimen preparation techniques for the imaging of materials.
- To envisage the imaging techniques for bulk and nano materials.
- To study and analyse the electron microscopy and its applications.
- To learn the advanced imaging techniques using atomic forces.

COURSE OUTCOMES:

- Understand the concept and classification of imaging system.
- Study of electron microscopy and its applications.
- Gain knowledge on imaging of nano materials.
- Differentiate morphology and topography of nano materials.
- Cultivate the imaging using atomic forces.
UNIT I  OPTICAL MICROSCOPY  9

UNIT II  SCANNING ELECTRON MICROSCOPY  12

UNIT III  TRANSMISSION ELECTRON MICROSCOPY  9

UNIT IV  ATOMIC FORCE MICROSCOPY (SCANNING PROBE MICROSCOPY)  9
Basic concepts - interaction force - AFM and the optical lever - scale drawing - AFM tip on nano meter scale structures - force curves, measurements and manipulations - different modes of operation – contact and non-contact mode - imaging and manipulation of samples in air/liquid environments - imaging of soft samples - shear force microscopy - lateral force microscopy - magnetic force microscopy.

UNIT V  SCANNING TUNNELING MICROSCOPY  6

TOTAL: 45 PERIODS
REFERENCE BOOKS:


13NT205 : NANOTECHNOLOGY IN HEALTH CARE

COURSE OBJECTIVES:

- To gain basic knowledge about biological molecules and various methods in nano scale reactions.
- To understand the recent trends in biotechnology.
- To be aware of nano scale experiments in immuno technology.
- To design various disease diagnosis methods based on nanotechnology.
- To device treatments and nano drug delivery methodologies.

COURSE OUTCOMES:

- Understand biological systems and design nano devices using biomimicry.
- Design nano devices to solve biological problems.
- Understand techniques in biotechnology which helps in designing nano probes and nano scaffolds.
• Detect tumors and other diseases using in-vivo imaging and sensors.
• Recognize the cancer treating methods using nano medicines.

UNIT I  NANO BIOLOGY AND BIOCONJUGATION OF NANO MATERIALS  10

Properties of DNA and motor proteins - Reactive groups on biomolecules (DNA & Proteins) - Surface modification and conjugation to nano materials - Lessons from nature on making nano devices - Fabrication and application of DNA nanowires - Nano fluidics to solve biological problems.

UNIT II  TRENDS IN BIOTECHNOLOGY  9

Nanotechnology in gene therapy - PCR, ELISA, DNA profiling and blotting techniques - nanoprobes, nano scaffolds - stem cell technology.

UNIT III  IMMUNO TECHNIQUES IN NANO SCIENCES  8

Immunoassay and immuno sensors - bio-barcode assay - use of magnets, gold, DNA and antibodies - magnetic nanoparticles.

UNIT IV  NANO TECHNOLOGY BASED MEDICAL DIAGNOSTICS  9

Improved diagnosis by in vivo imaging - detection of tumors and central nervous system disorders, plaque and genetic defects, nano bot medical devices - cantilever sensors.

UNIT V  NANO DRUG DELIVERY AND NANO MEDICINE  9

Properties of nano carriers - drug delivery systems used in nano medicine - enhanced permeability and retention effect - blood-brain barrier - active and passive targeting of diseased cells - health and environmental impacts of nanotechnology.
TOTAL: 45 PERIODS

REFERENCE BOOKS:


13NT206 : NANOELECTRONIC DEVICES AND NANOSensors

COURSE OBJECTIVES:

- To make students to learn the basic concepts of nanoelectronics.
- To enable the students to understand the quantum devices.
- To enable the students to know the tunneling devices and its uses.
- To make the students to analyze the superconducting devices and photonics.
- To make students to learn the basic concepts of nano sensors and its applications.

COURSE OUTCOMES:

- To understand basic and advanced concepts of nano electronic devices, sensors and transducers and their applications in
nanotechnology.

- To design advanced electronic systems integrated on a miniaturized Silicon chip.
- To have detailed knowledge of the operation of micro- and nano-scale devices, their applications and the technologies used to fabricate them.
- To analyse & design a range of devices using relevant mechanical/electrical engineering principles.
- Apply the basic nano sensor concepts for their applications.

UNIT I  BASICS OF NANO ELECTRONICS  9


UNIT II  QUANTUM DEVICES  9


UNIT III  TUNNELING DEVICES  9

UNIT IV SUPERCONDUCTING DEVICES AND PHOTONICS


UNIT V NANO SENSORS


TOTAL: 45 PERIODS

REFERENCE BOOKS:


COURSE OBJECTIVES:

- To make students to learn the basic experimental analysis of optical microscopy.
- To enable the students to understand the imaging using SEM.
- To facilitate the students to know the topography of nano materials using AFM.
- To test the nano materials property by nano indentation & F/D curve.
- To make students to learn the roughness concepts of nano particles using AFM.

COURSE OUTCOMES:

- Understand the practice of various imaging systems.
- Morphology of nano particles using SEM.
- Topography and roughness studies using AFM.
- Practicing various AFM modes.
- Electro deposition of nano materials.

LIST OF EXPERIMENTS:

1. Determination of size and lateral dimensions of various samples (pollen grains, strands of hair) using optical microscope.
2. Synthesis of SiO$_2$ polysphere film and morphology characterization using an optical microscope.
3. Surface topography of SiO$_2$ film using AFM.
4. Surface topography of a polymer film on glass using AFM in the non-contact mode; phase imaging
5. Nano indentation on a polycarbonate substrate using AFM; F-D curves and hardness determination.
6. Surface topography of a freshly cleaved mica.
7. Sol-gel spin coating route to SnO$_2$ nano thin films: surface roughness measurement by AFM.

8. Electro deposition of Cu nano structures and its morphology.

9. Surface topography of a metal film prepared by sputtering using AFM.

13NT252 : MINI PROJECT  
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COURSE OBJECTIVES:

- To well verse about the knowledge in nano particle synthesis.
- To facilitate idea in isolating nano particles.
- Effective training in characterization of nano particles.
- To give a strong foundation towards proceeding main project.
- To familiarize about various nano based materials used in different applications.

COURSE OUTCOMES:

- Able to follow different synthetic strategies adopted for isolating nano particles.
- Familiarized in the characterization of nano materials.
- Able to elucidate the structural behavior, purity and other important features of nano materials.
- Knows about uniqueness of nano particles.
- Getting trained in isolation, tuning towards specific applications.

Based on the literatures, knowledge gained in the theory subjects and facilities available at the lab, every student has to individually synthesis / develop a nano material with minimum of four related characterizations in detail with proper justification.

*Internal Assessment only*
III SEMESTER
13NT301 : LITHOGRAPHY AND NANOFABRICATION

COURSE OBJECTIVES:

Lithography is a study of printing micron to nano scale features on silicon wafer. Complete understanding of the course makes the student technically strong in nano fabrication.

- To impart sound knowledge about the fundamentals of clean room and nano fabrication by optical projection lithography.
- To emphasize about the importance of mask and maskless lithography.
- To motivate the pattern transfer technique with high energetic electron beam concepts.
- This course provides information about printing the pattern with ion beam sources.
- To enable the knowledge about printing with soft lithographic concepts and etching the unwanted portions.

COURSE OUTCOMES:

- It emphasize about the fabrication of integrated circuits on microchip using optical principles.
- Understand about the extreme UV light and zone plates as maskless techniques.
- Applying scanning electron beam techniques in nano fabrication.
- Imparts knowledge about the use of Ion beam/focussed ion beam as tools for developing nano objects.
- Provides impression about soft lithography techniques and various modes of etching.
UNIT I INTRODUCTION TO LITHOGRAPHY

Introduction to lithography – lithography processes; mask making, wafer pre-treatment, resist spinning – pre-bake, exposure, development and rinsing, post-bake, resist stripping, positive and negative photoresists – lift off profile - introduction to semiconductor processing - necessity for a clean room - different types of clean rooms - maintenance of a clean room – micro fabrication process flow diagram – chip cleaning, coating of photoresists, patterning, etching, inspection – process integration - etching techniques - reactive Ion etching - magnetically enhanced RIE-Ion beam etching - other etching techniques.

UNIT II PHOTOLITHOGRAPHY AND PATTERNING OF THIN FILMS


UNIT III DIRECT WRITING METHODS - MASKLESS OPTICAL LITHOGRAPHY


UNIT IV ELECTRON BEAM LITHOGRAPHY, ION BEAM & X-RAY LITHOGRAPHY

Scanning electron - beam lithography - electron sources and electron optics system – maskless EBL- electron beam projection lithography -
scattering with angular limitation projection e-beam lithography - projection reduction exposure with variable axis immersion lenses - Ion beam lithography - focusing ion beam lithography - ion projection lithography – X-ray lithography – X-ray masks, resists, merits and demerits - atom lithography.

UNIT V NANOIMPRINT LITHOGRAPHY AND SOFT LITHOGRAPHY


TOTAL: 45 PERIODS

REFERENCE BOOKS:


COURSE OBJECTIVES:

- Gain knowledge in the synthesis of nanoparticles.
- Obtain idea about the process control parameters in the synthesis.
- Familiarise on the various characterisation techniques.
- Interpret on the structural and functional behaviour of nanoparticles.
- Know about the fundamental behaviour of nanoparticles for functional applications.

COURSE OUTCOMES:

- Able to synthesise wide variety of nanoparticles.
- Capable of formulating nanoparticles for desired applications.
- Gain knowledge in the characterisation techniques.
- Able to predict the structural and functional behaviour of nanoparticle.
- Expertise in synthesis and analyse the fundamental behaviour of nanostructures.
- Based on the literatures, knowledge gained in the theory subjects every student has to individually prepare a proposal to develop a nano material for certain applications.
- Synthesis by chemical route/ PVD/ mechanical milling method etc.,
- The broad areas will be synthesis and characterization of nano material with proper justification.
IV SEMESTER

13NT451 : PROJECT WORK (PHASE –II) L T P C
0 0 24 12

COURSE OBJECTIVES:

- To optimize the synthesis method for specific product.
- To completely evaluate the developed material for applications.
- Gain knowledge in advanced characterisation techniques.
- To get hands-on experience in handling the characterisation tools.
- To make a product for social welfare.

COURSE OUTCOMES:

- Able to synthesis particles with unique functionalities.
- Ability to handle the various characterisation equipments.
- Manipulate the nanoparticles for desired applications.
- Capable of converting the nanomaterial into products.
- Able to publish the work in research articles.

It is the continuation of Phase I project.

- Optimization of synthesis method for a specific product.
- Complete evaluation of the developed material by various characterization tools with Justification.
- Synthesized and characterized material has to be converted in to a product.
- The final product has to be demonstrated at the end of the phase.
ELECTIVES
13NT401 : TOP DOWN MANUFACTURING METHODS
L T P C
3 0 0 3

COURSE OBJECTIVES:

• To provide basic knowledge in lithographic techniques.
• To obtain the knowledge about advanced lithographic techniques.
• To know about etching process followed after lithography.
• To have an idea about the development of nano crystalline ceramics using ball mill.
• To know about different micro milling processes.

COURSE OUTCOMES:

Upon completion of the course the students will be able

• To develop various lithographic techniques with etching techniques.
• To advance knowledge on E-beam and ion beam lithography.
• To develop ball milling processes to fabricate nano crystalline materials.
• To gain knowledge on micro milling/machining techniques.
• To differentiate the types of micro milling processes.

UNIT I INTRODUCTION

Introduction to micro fabrication and Moore’s law – importance of lithographic techniques - different types of lithographic techniques - optical projection lithography – photo mask - binary mask - phase shift mask - optical immersion lithography - maskless optical projection lithography - zone plate array lithography - extreme ultraviolet lithography.
UNIT II  E-BEAM AND ION BEAM LITHOGRAPHY  15

Principle and instrumentation - scanning electron-beam lithography - mask less (ML2) EBL - parallel direct-write e-beam systems - E-beam projection lithography - PREVAIL X-ray lithography - focused ion beam lithography - ion projection lithography - masked ion beam direct structuring – nano imprint lithography - soft lithography - dip-pen lithography.

UNIT III  ETCHING TECHNIQUES  5

Reactive ion etching - RIE reactive ion etching - magnetically enhanced RIE - ion beam etching - wet etching of silicon - isotropic etching - anisotropic etching - electrochemical etching - vapor phase etching - dry etching - other etching techniques.

UNIT IV  BALL MILLING TECHNIQUE  5

Nano powders produced using micro reactors – nano crystalline ceramics by mechanical activation - formation of nanostructured polymers.

UNIT V  MACHINING PROCESSES  8

Micro milling/micro drilling/micro grinding processes and the procedure for selecting proper machining parameters with given specifications - EDM micro machining, laser micro/nano machining - models to simulate micro/nano machining processes using molecular dynamics techniques - wet chemical etching - dry etching - thin film and sacrificial processes.

TOTAL: 45 PERIODS

REFERENCE BOOKS:


13NT402 : BOTTOM UP SYNTHESIS OF NANOSTRUCTURES  L  T  P  C
3 0 0 3

COURSE OBJECTIVES:

- To provide synthetic approach about thin films.
- Knowledge about physical vapour deposition on sputtering.
- To know about epitaxial growth of semi-conductor films.
- To have an idea about the development of thin film by chemical methods.
- To know about different printing technologies.

COURSE OUTCOMES:

Upon completion of the course the students will be able

- To develop thin films using CVD and other methods.
- To obtain thin films using sputtering methods.
- To develop epitaxial growth of thin films.
- To grow thin films using various chemical methods.
- To differentiate different types of printing techniques.

UNIT I THIN FILM TECHNOLOGIES – I  9

CVD chemical vapor deposition – atmospheric pressure CVD (APCVD) – low pressure CVD (LPCVD) - plasma enhanced chemical vapor deposition (PECVD) - HiPCO method – photo-enhanced chemical vapor deposition (PHCVD) - LCVD Laser – induced CVD.
UNIT II THIN FILM TECHNOLOGIES – II

Physical vapor deposition - sputter technologies - diode sputtering - magnetron sputtering - ion beam (sputter) deposition, ion implantation and ion assisted deposition - cathodic arc deposition - pulsed laser deposition.

UNIT III EPITAXIAL FILM DEPOSITION METHODS

Epitaxy, different kinds of epitaxy - influence of substrate and substrate orientation, mismatch, MOCVD metal organic chemical vapor deposition - CCVD combustion chemical vapor deposition - ALD atomic layer deposition - LPE Liquid phase epitaxy - MBE molecular beam epitaxy.

UNIT IV CHEMICAL METHODS


UNIT V PRINTING TECHNOLOGIES

Screen printing - inkjet printing - gravure printing and flexographic printing - flex graphic printing - gravure printing – roll to roll techniques.

TOTAL: 45 PERIODS

REFERENCE BOOKS:


COURSE OBJECTIVES:

- To provide fundamentals about semi-conducting materials.
- To provide various methods for synthesizing semi-conducting nano particles.
- To have a knowledge of physical properties of semi-conducting materials.
- To provide idea about the applications of semi-conducting materials.
- To give idea about the properties and preparation of nano wires.

COURSE OUTCOMES:

- Sound knowledge in semi-conductors.
- This will give idea about the synthetic strategies about the semi-conductor particles.
- It will provide all types of physical properties about the semi-conducting materials.
- Applications of semi-conducting materials will be gathered.
- Idea about nano wire properties, synthetic strategies will be gained.

UNIT I  SEMICONDUCTOR FUNDAMENTALS

UNIT II  SEMICONDUCTOR NANOPARTICLE SYNTHESIS

Cluster compounds - quantum-dots from MBE and CVD - wet chemical methods - reverse micelles - electro-deposition - pyrolytic synthesis - self-assembly strategies.

UNIT III  PHYSICAL PROPERTIES


UNIT IV  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 nano dots.

UNIT V  SEMICONDUCTOR NANOWIRES


TOTAL: 45 PERIODS

REFERENCE BOOKS:

3. Cao, Guozhong, “Nano structures and nano materials – synthesis,
properties and applications”, World Scientific Publisher Co., 2011.

WEB REFERENCES:

13NT404 : NANOTECHNOLOGY FOR ENERGY SYSTEMS

COURSE OBJECTIVES:

- To provide fundamentals about different types of energy sources.
- Idea about renewable energy sources will be provided.
- Familiarization about fuel cell, micro fuel cell technology is proposed.
- To gather idea about micro-fluidic devices, MEMS etc.,
- To provide knowledge about hydrogen storage with nano technology concepts.

COURSE OUTCOMES:

- Completion of this course gives sound knowledge about the fundamentals and types of energy sources.
- Renewable energy sources and its importance.
- Understanding the knowledge about fuel cell, micro fuel cell technology is provided.
- Idea about micro fluidic devices like piezo electric membrane.
- Knowledge about hydrogen storage for automotive applications.

UNIT I INTRODUCTION

Nanotechnology for sustainable energy - materials for light emitting diodes – batteries - advanced turbines - catalytic reactors – capacitors -
fuel cells.

UNIT II RENEWABLE ENERGY TECHNOLOGY 9

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 III MICRO FUEL CELL TECHNOLOGY 9


UNIT IV MICROFLUIDIC SYSTEMS 9

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

UNIT V HYDROGEN STORAGE METHODS 9

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.

TOTAL: 45 PERIODS

REFERENCE BOOKS:


2. D. Infield, “Hydrogen from renewable energy sources”,

90

13NT405 : MOLECULAR ELECTRONICS

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COURSE OBJECTIVES:

- To understand the basic concepts of organic molecules for molecular electronics applications.
- To acquire knowledge about unimolecular devices.
- To gain knowledge about the computer architecture of molecular electronic devices.
- To understand the fabrication technologies of molecular electronic devices.
- To gain knowledge about hybrid nano materials for biomolecular optoelectronic device.

COURSE OUTCOMES:

- Gain knowledge about material properties used in molecular electronics.
- Able to design advanced unimolecular electronic devices.
- Capable of interpreting the computing architectures of molecular electronic devices.
- Able to fabricate optoelectronic and thin film transistors.
- Able to process hybrid structures for biomolecular optoelectronic devices.
UNIT I  INTRODUCTION


UNIT II  UNIMOLECULAR ELECTRONICS

Organic semiconductor for new electronic device - photo voltaic cells - Schotkey diodes FET digital processing and communication with molecular switches.

UNIT III  MOLECULAR ELECTRONIC COMPUTING ARCHITECTURES

Molecular electronics overview – rectifiers - molecular wires – molecular switches – data storage - photo switches - molecular magnets.

UNIT IV  MOLECULAR ELECTRONIC DEVICES

Molecular engineering of doped polymer for optoelectronics - fabrication for molecular electronics organic FETs – organic thin film transistors.

UNIT V  BIO MOLECULAR ELECTRONICS AND PROCESSING


TOTAL: 45 PERIODS
REFERENCE BOOKS:


13NT406 : PRODUCT DESIGN, MANAGEMENT TECHNIQUES AND ENTREPRENEURSHIP

COURSE OBJECTIVES:

- To teach the concept of product design, entrepreneurship and management principles to the students.
- The method of preparing the feasibility report will be explained to the students.
- Knowledge on various related concepts like supply chain management, product launching and so on.

COURSE OUTCOMES:

- Gain knowledge on the product design methodology.
- Acquire knowledge on various management principles.
- Gain information on entrepreneurship.
- The knowledge on project profile preparation will be gained.
- The knowledge on supply chain management, global management will be gained.
UNIT I  PRODUCT DESIGN  9
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  PRODUCT DEVELOPMENT  9
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  MANAGEMENT TECHNIQUES  9
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  ENTREPRENEURIAL COMPETENCE & ENVIRONMENT  9
Concept of entrepreneurship - entrepreneurship as a career - personality
characteristic successful entrepreneur - knowledge and skill required for
an entrepreneur - business environment - entrepreneurship development
training - centre and state government policies and regulations - international
business.

UNIT V  MANAGEMENT OF SMALL BUSINESS  9
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.

TOTAL: 45 PERIODS
REFERENCE BOOKS:


13NT407 : MEMS AND BIO MEMS

COURSE OBJECTIVES:

- This course will provide basic platform about MEMS and its fabrication methods.
- Offer knowledge about thermal actuator, thermal sensor and its scaling methods.
- Provide basic idea about micro system design, micro accelerometer etc.
- Provides fundamentals about material to be used for fabricating MEMS.
- Idea about commercialization of miniaturized products.

COURSE OUTCOMES:

- On completion of this course, the student will have an idea about MEMS, its fabrication methods.
• The designing of thermal sensors, thermal actuators and its mechanics will be familiarized.
• Idea about the materials to be used for designing MEMS will be offered.
• Students get knowledge about micro accelerometer, thin film techniques etc.
• Give platform about commercialization of high density chip, lab-in-chip for DNA etc.

UNIT I    MEMS MICRO FABRICATION  10


UNIT II   SCALING OF MEMS  9

Introduction to scaling Issues - scaling effects on a cantilever beam - scaling of electrostatic actuators - scaling of thermal actuator - scaling of thermal sensors - mechanics and electro statistics - influence of scaling on material properties.

UNIT III  MICROSYSTEMS  10


UNIT IV  MATERIALS FOR MEMS  8

Materials for MEMS and pro MEMS - silicon-metals and polymers - substrate materials for MEMS - silicon-quartz – ceramics - bulk metallic glasses - sharp memory alloys, carbon based MEMS.
UNIT V COMMERCIAL AND TECHNOLOGICAL TRENDS


TOTAL: 45 PERIODS

REFERENCE BOOKS:


13NT408 : NANOCOMPOSITES

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COURSE OBJECTIVES:

- To understand the basic difference between composites and nano composites.
- To learn different preparation techniques for nano composites.
• To design and study the super hard nano composite coatings for different applications.
• To enable the methods for fabrication of polymer based nano composites.
• To know the concept of core-shell structured nano composites.

COURSE OUTCOMES:
• Understand the concept and classification of composites.
• Designing of super hard coatings and its applications.
• Gain knowledge on nano composite manufacturing methods.
• Information on new kinds of nano materials.
• Cultivate the industrial possibilities of polymer nano composites.

UNIT I   NANOCERAMICS
Metal-oxide or metal-ceramic composites - different aspects of their preparation techniques and their final properties and functionality.

UNIT II  METAL BASED NANOCOMPOSITES
Metal-metal nanocomposites - some simple preparation techniques and their new electrical and magnetic properties.

UNIT III DESIGN OF SUPER HARD MATERIALS
Super hard nanocomposites - its designing and improvements of mechanical properties.

UNIT IV  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 V   POLYMER BASED NANOCOMPOSITES
Preparation and characterization of di block copolymer based
nanocomposites – polymer-carbon nanotubes based composites their mechanical properties - industrial possibilities.

TOTAL: 45 PERIODS

REFERENCE BOOKS:


WEB REFERENCES:


13NT409 : CHEMICAL NANOTECHNOLOGY

L T P C

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COURSE OBJECTIVES:

• To understand the concept of chemistry of nano particles, molecular self-assembly etc.

• To educate about different types of polymeric materials and its
applications.

- To have knowledge about macromolecular system like dendrimer, molecular switches etc.
- To emphasize about the catalytic activities of nano particles, use of nano particles in different chemical reactions etc.
- To study about the background of electrochemical concepts available in semi-conductors, metal oxides etc.

COURSE OUTCOMES:

- Offered fundamentals of chemistry behind the organic molecular templates, self-assembly of molecules etc.
- Gathering of knowledge about polymeric molecules and its applications in various fields.
- Knowledge about molecular switches, dendrimer preparations, its applications.
- Emphasize about nano catalysis in different fields.
- Utilization of electrochemical based principles in different fields.

UNIT I CHEMISTRY OF NANOPARTICLES


UNIT II ADVANCED POLYMERIC MATERIALS

UNIT III  SUPRA MOLECULAR CHEMISTRY  
Catenanes and rotaxanes – synthesis and uses as molecular switches – dendrimers – preparations – classifications – applications.

UNIT IV  NANO CATALYSIS  

UNIT V  ELECTROCHEMISTRY OF NANOMATERIALS  

TOTAL: 45 PERIODS

REFERENCE BOOKS:


13NT410 : NANOPARTICLES AND MICRO ORGANISMS BIO NANO COMPOSITES

COURSE OBJECTIVES:

- To understand the biosynthesis of nano materials and its toxicity.
- To learn about the biomimetic synthesis of nanocomposite materials.
- To learn the basic concepts of bioelectronic devices.
- To cultivate the idea about novel drug delivery routes.
- To know the concept of tissue engineering for biomedical applications.

COURSE OUTCOMES:

- Able to synthesis nanoparticles through microorganisms.
- Ability to develop synthetic nanocomposites by biomimetic route.
- Capable of designing nanoparticle-enzyme hybrids based bioelectronic systems.
- Able to target diseases using nano mediated drug delivery systems.
- Understand the fundamentals of tissue engineering.

UNIT I MICROORGANISMS FOR SYNTHESIS OF NANO MATERIALS

Natural and artificial synthesis of nanoparticles in microorganisms - use of microorganisms for nanostructure formation - testing of environmental toxic effect of nanoparticles using microorganisms.
UNIT II  NANOCOMPOSITE BIOMATERIALS

Natural nanocomposite systems as spider silk, bones, shells - organic-inorganic nanocomposite formation through self-assembly - biomimetic synthesis of nanocomposite material - use of synthetic nanocomposites for bone, teeth replacement.

UNIT III  NANO BIO 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 nano circuitry. Protein based nano circuitry; Neurons for network formation - DNA nanostructures for mechanics and computing and DNA based computation - DNA based nano mechanical devices - biosensor and biochips.

UNIT IV  NANOPARTICLES AND NANO DEVICES


UNIT V  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.

TOTAL: 45 PERIODS

REFERENCE BOOKS:


13NT411 : OPTICAL PROPERTIES OF NANOMATERIALS, NANOPHOTONICS AND PLASMONICS

COURSE OBJECTIVES:

- To introduce the fundamental principles of nano metal particles.
- To provide various semi conducting nano materials.
- To know the physics of linear & nonlinear photonic crystals.
- To have thorough knowledge about plasmonics.
- To familiarize the applications of plasmonics.

COURSE OUTCOMES:

Upon completion of the course the students will be able

- To know the properties and nature of nano metal powders.
- To obtain the technical knowledge on semi conducting nano materials.
- To classify the linear & nonlinear photonic crystals.
- To identify the various materials for linear & nonlinear photonic crystals.
- To apply the plasmonics for real time applications.
UNIT I METAL NANOPARTICLES

Metal nanoparticles - alloy nanoparticles - stabilization in sol, glass and other media - change of band gap – blue shift - colour change in sol, glass, and composites - plasmon resonance.

UNIT II 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’s and solar cells – electroluminescence - barriers to nanoparticle lasers - doping nanoparticles - Mn-ZnSe phosphors - light emission from indirect semiconductors - light emission from Si nano dots.

UNIT III PHYSICS OF LINEAR PHOTONIC CRYSTALS

Maxwell’s equations - Bloch’s theorem - photonic band gap and localized defect states - transmission spectra - nonlinear optics in linear photonic crystals - guided modes in photonic crystals slab.

UNIT IV PHYSICS OF NONLINEAR PHOTONIC CRYSTALS

1-D quasi phase matching - nonlinear photonic crystal analysis - applications of nonlinear photonic crystals devices - materials: LiNbO\textsubscript{3}, chalcogenide glasses etc. - wavelength converters etc.

UNIT V ELEMENTS OF PLASMONICS

Plasmonics, merging photonics and electronics at nano scale 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.

TOTAL: 45 PERIODS
REFERENCE BOOKS:


WEB REFERENCES:


13NT412 : ADVANCED NANO DRUG DELIVERY SYSTEMS

COURSE OBJECTIVES:

- To understand about fundamentals of nano drug carriers.
- To gain knowledge about dendrimers and its poly valency properties.
- To learn about ligand based drug delivery.
- To learn the basics of drug targeting and bacterial and virus dependent delivery of vaccines.
- To understand basic concepts of drug delivery systems.

COURSE OUTCOMES:

- Learn the pharmacokinetics of different modes of drug delivery.
• Gain Knowledge about dendrimers and its uses for efficient drug delivery.
• Ability to design lipid based drug delivery systems.
• Know about virus based nanoparticles for drug targeting and biomedical imaging.
• Understand MEMS technology for fabrication of implantable microchips.

UNIT I THEORY OF ADVANCED DRUG DELIVERY 10


UNIT II POLYMERS 8

Dendrimers - synthesis – nano scale containers - dendritic nano scaffold systems - biocompatibility of dendrimers, gene transfection - pH based targeted delivery - chitosan and alginate - copolymers in targeted drug delivery - PCL - PLA - PLGA.

UNIT III LIPID BASED NANO CARRIERS 9

Liposomes - niosomes and solid lipid nanoparticles - ligand based delivery by liposomes - cubosomes.

UNIT IV MICROBES AND ANTIBODY BASED NANO CARRIERS 9

Bacterial dependent delivery of vaccines - drug delivery and subcellular targeting by virus - drug packaging and drug loading - delivery of therapeutics by antibodies and antibody - bioconjugates.

UNIT V SITE SPECIFIC DRUG DELIVERY 9

TOTAL: 45 PERIODS

REFERENCE BOOKS:


13NT413 : BIO MOLECULAR MACHINES

COURSE OBJECTIVES:

- To understand about fundamentals of molecular scale machines.
- To gain knowledge about bio molecular machines.
- To learn about molecular nano reactors.
- To learn the basics of logic gate memories.
- To understand the basic concepts of nano scale devices.

COURSE OUTCOMES:

- Learn the types of molecular machines & switches.
- Gain knowledge about bio molecular machines.
- Ability to design molecular nano reactors.
- Know about logic gate memories.
- Understand the fabrication of nano scale devices.

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UNIT I MOLECULAR SCALE-MACHINE

UNIT II BASIC PRINCIPLES OF MOTOR DESIGN
Biomolecular machines: transcription, translation and replication processes at single molecule level – initiation and force control of biological processes - force generation and real-time dynamics – active transport by biological motors – mechanism, dynamics and energetic of kinesin, myosin, dyneins and ATP synthesis.

UNIT III NANO REACTORS
Self-assembled nano reactors - molecular nano reactors - covalent system - nano covalent system - macro molecular nanoreactions micelles and polymers – biomacro molecular nanoreactions - protein cages-viruses - rod shaped and cage structured.

UNIT IV MEMORIES, LOGIC GATES AND RELATED SYSTEMS
Memories logic gates – multistate – multifunctional systems.

UNIT V NANO SCALE DEVICES
Fabrication and patterning of nano scale device.

TOTAL: 45 PERIODS

REFERENCE BOOKS:
13NT414 : BIOSENSORS

COURSE OBJECTIVES:

- To understand about protein based biosensors.
- To gain knowledge about DNA based biosensor.
- To learn about detection techniques of biosensors.
- To learn the basics of micro fabrication of electrodes.
- To understand the basic concepts of molecular design of biosensors.

COURSE OUTCOMES:

- Learn about the materials used in protein based biosensors.
- Determine the complex metals in food samples by DNA based biosensor.
- Ability to differentiate detection techniques of biosensors.
- Able to fabricate electrodes for biosensing.
- Understand cellular biosensing techniques.

UNIT I  PROTEIN BASED BIOSENSORS  9


UNIT II  DNA BASED BIOSENSOR  9

Heavy metal complexing with DNA and its determination - water and food samples – DNA zymo biosensors.

UNIT III  BIOSENSOR  BASED  DETECTION TECHNIQUES  9

Detection in biosensors - fluorescence - absorption – electrochemical.
Integration of various techniques – fiber optic biosensors.

UNIT IV  FABRICATION  9

Techniques used for micro fabrication – micro fabrication of electrodes on chip analysis.

UNIT V  MOLECULAR DESIGN  9

Future direction in biosensor research - designed protein pores as components of biosensors - molecular design - bionanotechnology for cellular biosensing - biosensors for drug discovery – nano scale biosensors.

TOTAL: 45 PERIODS

REFERENCE BOOKS:

13NT415 : BIOPHOTONICS  L  T  P  C
3 0 0 3

COURSE OBJECTIVES:
- To understand the interaction of light with biological systems.
- To learn the principles of various imaging techniques.
- To gain knowledge about single molecule spectroscopy.
- To learn the basics of optical trapping technologies.
- To understand basic bio detection techniques.

COURSE OUTCOMES:
- Learn the effects of light with body organelles.
- Capable of operating imaging tools.
- Ability to differentiate various spectroscopy techniques.
- Understand the optical confinement phenomena for trapping applications.
- Able to detect cellular and molecular tags.

UNIT I  INTRODUCTION

Interaction of light with cells, tissues - non-linear optical processes with intense laser beams - photo-induced effects in biological systems.

UNIT II  IMAGING TECHNIQUES


UNIT III  SINGLE MOLECULE SPECTROSCOPY

UV-Vis. spectroscopy of biological systems - single molecule spectra and characteristics – IR and raman spectroscopy and surface enhanced raman spectroscopy for single molecule applications.

UNIT IV  ANALYTICAL BIOTECHNOLOGY

Optical force spectroscopy: generation optical forces – optical trapping and manipulation of single molecules and cells in optical confinement - laser trapping and dissection for biological systems - single molecule biophysics.

UNIT V  DETECTION TECHNIQUES

Biosensors - fluorescence immunoassay - flow cytometry - fluorescence correlation spectroscopy - fluorophores as cellular and molecular tags.

TOTAL: 45 PERIODS

REFERENCE BOOKS:

1. Michael P. Sheetz (Ed.), “Laser tweezers in cell biology and

13NT416 : NANOTOXICOLOGY  L  T  P  C
3  0  0  3

COURSE OBJECTIVES:
- To understand about fundamentals of toxicology.
- To learn about risk on nano toxicology.
- To gain knowledge about protocols in toxicology studies.
- To learn the animal studies on toxicology.
- To understand concepts on risk assessment and execution.

COURSE OUTCOMES:
- Learn the toxicological terminology.
- Gain knowledge about nano toxicity.
- Ability to assess toxicity of nano materials.
- Know about dosing profile for animal models.
- Exposure on the regulations of toxicity.

UNIT I  INTRODUCTION TO TOXICOLOGY  9

UNIT II  NANO TOXICOLOGY  9
Characteristics of nanoparticles that determine potential toxicity - bio-

UNIT III PROTOCOLS IN TOXICOLOGY STUDIES 10


UNIT IV ANIMAL MODELS 9

Types, species and strains of animals used in toxicity studies - dosing profile for animal models - studies on toxicology - pathology and metabolism in mouse and rat - laws and regulations - governing animal care and use in research.

UNIT V RISK ASSESSMENT AND EXECUTION 8

Risk assessment of nanoparticle exposure - prevention and control of nano particles exposure - regulation and recommendations.

TOTAL: 45 PERIODS

REFERENCE BOOKS:


13NT417: ADVANCED NANO BIOTECHNOLOGY  L  T  P  C
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COURSE OBJECTIVES:

• To gain knowledge about natural nanocomposites for agricultural applications.
• To learn the principles of bio delivery systems.
• To gain knowledge about design strategies of protein and DNA nanostructures.
• To learn the basics of nano bioelectronics.
• To understand applications of nanoparticles in therapeutic and diagnostic applications.

COURSE OUTCOMES:

• Able to differentiate synthetic and natural nanocomposites and its applications.
• Capable of synthesizing thermo responsive delivery systems.
• Ability to fabricate biomimetic nanostructures.
• Understand the bio recognition techniques of nanoparticles.
• Able to understand the role of nanoparticles in cancer therapy.

UNIT I  NATURAL NANOCOMPOSITES  9

Natural nano composite materials – biomineralisation – biologically synthesized nano structures – metals, ceramic and silica deposition vesicles –nanotechnology in agriculture - fertilizers and pesticides.
UNIT II  SMART NANO PARTICULATE SYSTEMS

Thermo responsive delivery systems - pH responsive delivery systems - external stimuli based delivery systems (magnetic, photosensitive and ultra sound sensitive delivery systems) – stealth nanoparticles - multi targeting systems.

UNIT III  PROTEIN AND DNA BASED NANOSTRUCTURES


UNIT IV  NANO BIOELECTRONICS


UNIT V  THERAPEUTIC AND DIAGNOSTIC APPLICATIONS OF NANOPARTICLES

Gene therapy using nanoparticles – nanofluids (aqueous dispersed applications of nanoparticles) – nanoparticles in bioanalytical techniques (quantum dots, SPR based and peptide based sensors) – advances in cancer therapy.

TOTAL: 45 PERIODS

REFERENCE BOOKS: