M. TECH. NANOTECHNOLOGY
CURRICULUM AND SYLLABUS
2012-2013

Eligibility: B.E./B.Tech. (Any Specialization), M.Sc. (Physics/Material Science/Chemistry/ Applied Chemistry/Bio-chemistry/Biotechnology) with Mathematics as one of the subjects at B.Sc. level

Guideline for Selecting Courses

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<th>SI. No.</th>
<th>Category</th>
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Duration: 2 years in 4 Semesters

CORE COURSES

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## PROGRAM ELECTIVES

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2 NT – 12–13 – SRM – E&T
Total no. of credits to be earned for the award of degree: 72

OPEN ELECTIVES (offered to other branch students)

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SYLLABUS

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PURPOSE

The intended course covers the whole spectrum of nanomaterials ranging from overview, synthesis, properties, and characterization of nanophase materials to application including some new developments in various aspects.

INSTRUCTIONAL OBJECTIVES

1. Beginners will be able to acquaint themselves with the excited subject though they are novice, whereas advanced learners will equip themselves to solve the complicated issues further.

2. To know the importance of the synthesis method addressed in the material properties and give practical experience of nanomaterials synthesis/properties and characterization; investigations into the various factors influence the properties of nanomaterials, optimizing the procedures, and implementations to the new designs

3. To provide a sound understanding of the various concepts involved in fabrication of device architectures’ and able to evaluate them in advance

UNIT - I NANODIMENSIONAL MATERIALS


UNIT - II PHYSICO-CHEMICAL METHODS OF NANOSTRUCTURED MATERIALS


UNIT - III SPECIFIC FEATURES OF NANOSCALE GROWTH


UNIT - IV NANOSCALE PROPERTIES


UNIT - V CHARACTERIZATION OF NANOPHASE MATERIALS

PRACTICALS
1. Processing and Development of Nanoparticle gas sensor
2. Magnetic separation/identification studies of thermally-blocked nanoparticles
3. Harvesting of light using nano-solar cells
4. Nano-Forensic analysis to identify, individualize and evaluate evidence using nanophase materials
5. Scratch resistance enhancement study of polymer containing nanoparticles
6. Electrodeposition and corrosion behavior of nanostructured composite film
7. Photocatalytic activity of nanomaterials

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PURPOSE
To provide an introduction to the theory and practice of bio-nanotechnology

INSTRUCTIONAL OBJECTIVES
1. Understand the basic knowledge of Nanobiotechnology and DNA structures.
2. Understand the application of Nanomaterials in biotechnology and acquire the knowledge about the DNA, proteins, amino acids, drug delivery, biomedicine etc.,
3. To provide the knowledge in basics of nanotechnology in biotechnology.
4. To make the students understand about the functional principles of binanotechnology

UNIT - I BIONANOMACHINES AND THEIR BASICS

UNIT - II SYNTHESIS OF BIOMOLECULES & INTERPHASE SYSTEMS
Recombinant Technology, Site-directed mutagenesis, Fusion Proteins. Quantum Dot structures and their integration with biological structures. Molecular modeling tools: Graphic visualization, structure and functional prediction, Protein folding prediction and the homology modeling, Docking simulation and Computer assisted molecular

UNIT - III  FUNCTIONAL PRINCIPLES OF NANOBIOTECHNOLOGY
Information driven nanoassembly, Energetic, Role of enzymes in chemical transformation, allostery motion and covalent modification in protein activity regulation, Structure and functional properties of Biomaterials, Bimolecular motors: ATP Synthetase and flagellar motors, Traffic across membranes: Potassium channels, ABC Transporters and Bacteriorhodopsin, Bimolecular sensing, Self replication, Machine-Phase Bionanotechnology Protein folding; Self assembly, Self-organization, Molecular recognition and Flexibility of biomaterials.

UNIT - IV  PROTEIN AND DNA BASED NANOSTRUCTURES

UNIT - V  APPLICATIONS OF NANOBIOTECHNOLOGY
Semiconductor (metal) nanoparticles and nucleic acid and protein based recognition groups – Application in optical detection methods – Nanoparticles as carrier for genetic material – Nanotechnology in agriculture – Fertilizer and pesticides. Designer proteins, Peptide nucleic acids, Nanomedicine, Drug delivery, DNA computing, Molecular design using biological selection, Harnessing molecular motors, Artificial life, Hybrid materials, Biosensors, Future of Bionanotechnology

PRACTICALS
1. Nanostructured DNA Templates
2. Probing DNA structure with Nanoparticles
3. Fluoroimmunoassays using Antibody- conjugated Quantum Dots
4. Surface- Functionalized Nanoparticles for controlled Drug Delivery
5. Quantum Dot- encoded Beads
6. Ultrasensitive DNA sequence detection using nanoscale ZnO sensor arrays
7. Electrochemical Biosensors for the Detection of Pesticides
8. Membrane-Based Electrochemical Nanobiosensor for Escherichia coli Detection and Analysis of Cells Viability

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PURPOSE
To introduce to the students the basic principles of Nanophotonics.

INSTRUCTIONAL OBJECTIVES
1. To make the students acquainted with the concepts of Nanophotonics.
2. To describe the effects of quantization on the optical properties of semiconductors and metals
3. To determine the areas of opportunity in nanophotonic research
UNIT - I FOUNDATIONS FOR NANOPHOTONICS

UNIT - II QUANTUM CONFINED MATERIALS

UNIT - III PLASMONICS
Internal reflection and evanescent waves – plasmons and surface plasmon resonance – Attenuated Total reflection – Grating SPR coupling – Optical waveguide SPR coupling- SPR dependencies and materials – plasmonics and nanoparticles

UNIT - IV PHOTONIC CRYSTALS
Important features of photonic crystals - Presence of photonic bandgap-anomalous group velocity dispersion - Microcavity-effects in Photonic Crystals - fabrication of photonic Crystals - Dielectric mirrors and interference filters - photonic crystal laser - PBC based LEDs - Photonic crystal fibers (PCFs) - Photonic crystal sensing.

UNIT - V NEW APPROACHES IN NANOPHOTONICS
Near Field Optics - Apertureless near field optics - near field scanning optical microscopy (NSOM or SNOM) - SNOM based detection of plasmonic energy transport - SNOM based visualization of waveguide structures - SNOM in nanolithography - SNOM based optical data storage and recovery-generation of optical forces - optical trapping and manipulation of single molecules and cells in optical confinement - laser trapping and dissection for biological systems.

References:

NT0504 NANOLITHOGRAPHY AND DEVICE FABRICATION

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PURPOSE
The ultimate aim is to study about nanostructures fabrication and processing in detail and to exercise the learners’ knowledge and imagination of nanoscience and nanotechnology toward engineering applications coupled with detailed justifications.

INSTRUCTIONAL OBJECTIVES
1. Able to define the concepts involved in physics and chemistry of surfaces along with the fundamental interactions amongst them.
2. Understand the key concepts of lithographic and microscopic resolution and apply this knowledge to estimate the intrinsic resolution limits for manipulation and imaging/inspection tools; Redefining the concepts of contrast and a transfer function for all systems and explain their role in both microscopy and lithography;
3. Evolve how processing tools are applied to transfer nanostructured patterns into useful materials based on device architectures; analyze and evaluate proposed approaches to material processing to device designs in advance.
UNIT - I THE SCIENCE OF MINIATURIZATION

UNIT - II NANOSTRUCTURING BY PHYSICAL TECHNIQUES

UNIT - III NANOMANIPULATION AND PROCESSING
Conventional techniques: Scanning tunneling microscopy (STM) – Atomic force microscopy (AFM) – Near-field scanning optical microscopy (NSOM) – Advanced Techniques: Embossing and surface passivation, Dimensional Subtraction and Addition, Multistep Processing, of -Microcontact printing- Molding – implications and applications of the conventional and advanced techniques

UNIT - IV NANOMETER DEVICES

UNIT - V SUB-LITHOGRAPHIC ARCHITECTURES
Fundamental scaling limits to the transistors – Beyond CMOS: Self-Assembled structures – Gravitational field assisted assembly – Template-assisted assembly- Shear force assisted assembly - Electroforming and Molding (LIGA) – Fundamentals of Quantum Computing – Quantum Algorithms - Realizing quantum computers – Physical Implementations (Josephson junction Circuits and semiconductor quantum dots)

References:
The purpose of this course is to develop broader aspects in understanding the role of nano electronics and its application.

**INSTRUCTIONAL OBJECTIVES**

1. To understand the basic concepts involve in this technology for device architecture and interface engineering at atomic.
2. Give a general introduction to different types of conventional and novel nanoelectronic devices for different applications.
3. Understand the underlying physical processes governing the operation of spintronic devices.
4. Demonstrate how simulation can facilitate learning of fabrication process and device designing.

**UNIT - I QUANTUM DEVICES**

Charge and spin in single quantum dots - Coulomb blockade – Electrons in mesoscopic structures - single electron transfer devices (SETs) – Electron spin transistor – resonant tunnel diodes, tunnel FETs - quantum interference transistors (QUITs) - quantum dot cellular automata (QCAs) - quantum bits (qubits).

**UNIT - II NANOELECTRONIC DEVICES**

Electronic transport in 1, 2 and 3 dimensions - Quantum confinement – energy subbands - Effective mass - Drude conduction - mean free path in 3D - ballistic conduction - phase coherence length - quantized conductance - Buttiker-Landauer formula - electron transport in pn junctions - short channel NanoTransistor –MOSFETs - Advanced MOSFETs - Trigate FETs, FinFETs - CMOS.

**UNIT - III MOLECULAR NANOELECTRONICS**


**UNIT - IV SPINTRONICS**


**UNIT - V NANOELECTRONIC ARCHITECTURES AND COMPUTATIONS**


**PRACTICALS**

1. Process and Device Simulation of Single-Electron Transistor (SET)
2. SOI based nanowire single-electron transistor - Design, simulation and process development.
3. Simulation study of nanowire TFET device.
4. Process design and development of 30 nm CMOS inverter.
5. Characterization and analysis Double gate SOI MOSFET for nano electronic circuits.
6. Process and device simulation of Silicon Nanowire FinFET device.

**References:**


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**INSTRUCTIONAL OBJECTIVES**
1. To elucidate on advantages of nanotechnology based applications in each industry
2. To provide instances of contemporary industrial applications of nanotechnology
3. To provide an overview of future technological advancements and increasing role of nanotechnology in each industry

**UNIT - I  NANOTECHNOLOGY IN ELECTRICAL AND ELECTRONICS INDUSTRY**

**UNIT - II  NANOTECHNOLOGY IN BIOMEDICAL AND PHARMACEUTICAL INDUSTRY**

**UNIT - III  NANOTECHNOLOGY IN CHEMICAL INDUSTRY**
Nanocatalysts – Smart materials – Heterogeneous nanostructures and composites – Nanostructures for Molecular recognition (Quantum dots, Nanorods, Nanotubes) – Molecular Encapsulation and its applications – Nanoporous zeolites – Self-assembled Nanoreactors - Organic electroluminescent displays

**UNIT - IV  NANOTECHNOLOGY IN AGRICULTURE AND FOOD TECHNOLOGY**
Nanotechnology in Agriculture - Precision farming, Smart delivery system – Insecticides using nanotechnology – Potential of nano-fertilizers - Nanotechnology in Food industry - Packaging, Food processing - Food safety and bio-security – Contaminant detection – Smart packaging

**UNIT - V  NANOTECHNOLOGY IN TEXTILES AND COSMETICS**

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**PURPOSE**
To develop analytical capability and to impart knowledge in Mathematical and Statistical methods and their applications in Engineering and Technology and to apply these concepts in engineering problems they would come across.

**INSTRUCTIONAL OBJECTIVES**
1. At the end of the course, Students should be able to understand Mathematical and Statistical concepts and apply the concepts in solving the engineering problems.

**UNIT - I**
Initial and boundary value problems - Classification of Linear differential equation - solution of initial and boundary value problems. Laplace transform methods for one - dimensional wave equation - Displacements in a string. Fourier series methods for one dimensional wave equation and one - dimensional heat conduction problems.

**UNIT – II**
Probability - basic definition, conditional, Probability, Baye's theorem - Binomial, Poisson, Normal, Exponential, Rectangular, Gamma Distributions. Moment generating function, random variables, two dimensional random variables.

**UNIT – III**
Principle of least squares - Fitting of Straight line and parabola - Correlation - Linear multiple and partial correlation - Linear regression - Multiple regression.

**UNIT – IV**
Sampling distributions - Tests based on t-distribution, chi-square and F-distributions - Analysis of variance - One-way and two-way classifications.

**UNIT – V**

**References:**

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<th>NT0561</th>
<th>QUANTUM MECHANICS FOR NANOTECHNOLOGY</th>
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**PURPOSE**

To provide a working knowledge of the foundations, techniques, and key results of quantum mechanics. Comprehension of basic concepts will enable the students to apply quantum mechanics for solving problems in physics and nanotechnology.

**INSTRUCTIONAL OBJECTIVES**

1. To achieve an understanding of the theory of quantum mechanics, and an ability to apply the quantum theory to important physical systems
2. To appreciate the applications of quantum mechanics in physics, engineering, and related fields
3. To become aware of the necessity for quantum methods in the analysis of physical systems of atomic and solid state physics.
4. Explain scientifically the new applications of quantum physics in computation
5. To prepare the engineering students for advanced studies involving applications of quantum mechanics.

**UNIT - I  THE SCHRODINGER'S EQUATION AND ITS MATHEMATICAL IMPLICATION**


**UNIT - II  BOUND STATES & QUANTUM TUNNELING**

Free particle - Momentum eigen functions, Energy levels of a particle – Infinite square well in one, two, and three dimensions - Density of states – Confined carriers - Electron wave propagation in devices - Quantum confinement - Penetration of a barrier – Tunnel effect - Basic principles of a few effective devices – Resonant tunnel diode, Superlattice, Quantum wire and Dot.

**UNIT - III  QUANTUM DYNAMICS**

Time development of the wave function - Time evolution operator - Schrodinger, Heisenberg, and Interaction pictures of quantum dynamics -Time evolution - Free particle wave packet, One-dimensional harmonic oscillator, Two-state quantum systems.

**UNIT - IV  IDENTICAL PARTICLES AND SCATTERING THEORY**


**UNIT - V  QUANTUM COMPUTATION**

Quantum Bits - Single qubit gates - Multiple qubits – Controlled Not gate, Swap gate, Toffoli gate, Bell states - no-cloning theorem - Quantum Teleportation - Deutsch’s Algorithm - Deutsch-Jozsa Algorithm - Quantum Fourier transform.

**References:**


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<th>NT0562</th>
<th>STATISTICAL THERMODYNAMICS FOR NANOSYSTEMS</th>
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**PURPOSE**
To introduce to the students the basic principles of statistical thermodynamic principles for nanosystems and to lay emphasis on the fundamentals

**INSTRUCTIONAL OBJECTIVES**

1. The objective of this course is to make the students acquire depth of knowledge in the concepts of statistical mechanics and thermodynamics and to apply it to different nano scale systems
2. The objective of this course is to make the students understand the thermodynamics of small systems and non-equilibrium thermodynamics
2. The objective of this course is to make the students apply the principles of thermodynamics and statistical mechanics in new formulations

**UNIT - I THERMODYNAMICS OF SMALL SYSTEMS**

**UNIT - II NANOTHERMODYNAMICS**
Different Approaches to Nanothermodynamics-surface thermodynamics-Phase transitions in nanoparticles-quasi chemical description of solid nanoparticles-size dependent interface energy-thermodynamics of confined fluids in nanopores-structural properties of nanoclusters-Hill's approach to Nanothermodynamics-Phase transition in nanosystems-symmetry of fullerenes-PI index of some carbon nanotubes.

**UNIT - III NON-EQUILIBRIUM THERMODYNAMICS**

**UNIT - IV NONEQUILIBRIUM NANOSYSTEMS**

**UNIT - V THERMODYNAMICS OF BIOLOGICAL SYSTEMS**
Crystal-melt interfacial energies and solubilities for nanosized systems- Via the Ostwald-Freundlich equation, the size-selective growth process of nanoparticles-Bulk membrane partition- Nanothermodynamics of a Single Molecule- The Concept of Pseudoequilibrium- Cellular and Subcellular Systems.

**References:**

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<th>NT0563</th>
<th>SOLID STATE TECHNOLOGY</th>
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**PURPOSE**
The course aims at providing an overview of basic physics of solids and advanced topics in solid state materials of technological value.

**INSTRUCTIONAL OBJECTIVES**
1. To show how diverse properties (electronic, thermal, optical) of solid materials can be related to interactions at the atomistic level, using theoretical models.
2. To deduce and verify macroscopic properties of solids using standard theoretical models and understand their significance in wider context of solid materials.
3. To show how solid state physics forms vital part of developing materials of technological value.

**UNIT - I CRYSTAL BINDING AND ELASTIC CONSTANTS**

**UNIT - II PHONON DYNAMICS AND THERMAL PROPERTIES**

**UNIT - III ELECTRONIC PROPERTIES OF SOLIDS AND NANOSTRUCTURES**

**UNIT - IV ELECTRONIC TRANSPORT PHENOMENA AND OPTICAL PROCESSES**

**UNIT - V SEMICONDUCTOR TECHNOLOGY**

**References:**

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<tr>
<th>NT0564</th>
<th>CELL AND MOLECULAR BIOLOGY</th>
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**PURPOSE**
The course is to understand the basic concept of cell biology & To understand the cell organization and cell cycle, Acquire the knowledge of various signaling mechanisms

**INSTRUCTIONAL OBJECTIVES**
1. Students will understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles
2. Students will understand how these cellular components are used to generate and utilize energy in cells
3. Students will understand the cellular components underlying mitotic cell division
4. Students will apply their knowledge of cell biology to selected examples of changes or losses in cell function. These can include responses to environmental or physiological changes, or alterations of cell function brought about by mutation

**UNIT - I INTRODUCTION TO CELL BIOLOGY**

**UNIT - II ORGANIZATION AND CELL CYCLE**

**UNIT - III DNA STRUCTURE, AMINO ACIDS & PROTIENS**

**UNIT - IV ORGANELLES & MEMBRANE**

**UNIT - V SIGNALING & IMMUNOTECHNOLOGY**

**References:**

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<th>NTE501</th>
<th>SOCIETAL IMPLICATIONS OF NANOTECHNOLOGY</th>
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**PURPOSE**
To provide an adequate basic knowledge on social impact of nanoscience and nanotechnology.

**INSTRUCTIONAL OBJECTIVES**

1. To provide awareness to the engineering students about socio economic impact of nanotechnology and to handle the techniques effectively.

2. Understand the various social impact of nanotechnology trend and research.

3. To enhance the nanotechnology research by taking ethics and public opinion into consideration.

4. To understand of professional and ethical responsibility

**UNIT - I ECONOMIC IMPACT OF NANOTECHNOLOGY**
Socio-Economic Impact of Nanoscale Science - Managing the Nanotechnology Revolution: Consider the Malcolm Baldrige National Quality Criteria - The Emerging Nano Economy: Key Drivers, Challenges, and Opportunities - Transcending Moore's Law with Molecular Electronics and Nanotechnology - Semiconductor Scaling as a Model for Nanotechnology Commercialization - Sustaining the Impact of Nanotechnology on Productivity, Sustainability, and Equity.

**UNIT - II SOCIAL SCENARIOS**

**UNIT - III CONVERGING TECHNOLOGY AND GOVERNANCE**

**UNIT - IV ETHICS AND LAW**

**UNIT - V PUBLIC PERCEPTION AND PARTICIPATION**
References:

NTE502   NANOMEDICINE       L  T  P  C

POURSE
Nanomedicine involves the development and application of materials and devices to study biological processes and to treat disease at the level of single molecules and atoms

INSTRUCTIONAL OBJECTIVES
1. Understand the principles behind nanomedicine and understand the applications of Nanomaterials in medicine.
2. Impart knowledge about drug delivery systems
3. Impart the knowledge to apply the Nanomaterials in different medical applications
4. Impart knowledge about Nanoscale Diagnostics

UNIT - I  NANOMOLECULAR DIAGNOSTICS - ARRAY AND CHIPS

Nanoparticles for Molecular Diagnostics -Gold Nanoparticles -Quantum Dots for Molecular Diagnostics Magnetic Nanoparticles -Use of Nanocrystals in Immunohistochemistry -Imaging Applications of Nanoparticles Study ofChromosomes byAtomic ForceMicroscopy-Applications of Nanopore Technology for Molecular Diagnostics DNA–Protein and DNA–Nanoparticle Conjugates

UNIT - II  NANOMACHINES AND NANOBARCODES, NANOBIOSENSORS
DNA Nanomachines for Molecular Diagnostics -Nanobarcodes Technology -Nanobarcde Particle Technology for SNP Genotyping -Qdot Nanobarcde for Multiplexed Gene Expression Profiling -BiobarcodeAssay for ProteinsSingle-Molecule Barcoding System for DNA Analysis Nanoparticle-Based Colorimetric DNA Detection Method

Cantilevers as Biosensors for Molecular Diagnostics -CarbonNanotube Biosensors -FRET-BasedDNA Nanosensors. Ion Channel Switch Biosensor Technology -Electronic Nanobiosensors -Electrochemical Nanobiosensors -Quartz Nanobalance Biosensors -Viral Nanosensors -PEBBLENanosensors -Microneedle-Mounted Biosensors OpticalBiosensors- Nanowire (NW) Biosensors -Nanoscale ErasableBiodetectors

UNIT - III  NANOPHARMACEUTICALS

UNIT - IV ROLE OF NANOTECHNOLOGY IN BIOLOGICAL THERAPIES

UNIT - V APPLICATION IN CANCER THERAPY & NANOMEDICINE

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<td>NTE503</td>
<td>NANOTECHNOLOGY IN ENERGY CONVERSION AND STORAGE</td>
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PURPOSE
The purpose of this course is an introduction to various forms of energy used in industries and methods of converting from one form to another by using Nanotechnology. Students should be provided with the opportunity to explore these various forms of energy, particularly in terms of Nanotechnology and how they are converted and how their use impact on the environment.

INSTRUCTIONAL OBJECTIVES
1. To demonstrate knowledge of the sources of energy and the methods of energy Conversion in Nanotechnology.
2. To appreciate the role of Nano technology in energy and its efforts to improve lifestyle.
4. To conduct experiments to verify basic principles of energy conversion.

UNIT - I INTRODUCTION
Nanotechnology for sustainable energy- Energy conversion process, indirect and direct energy conversion-Materials for light emitting diodes-batteries-advanced turbines-catalytic reactors-capacitors-fuel cells.

UNIT - II RENEWABLE ENERGY TECHNOLOGY
Energy challenges, development and implementation of renewable energy technologies - nanotechnology enabled renewable energy technologies - Energy transport, conversion and storage- Nano, micro, and poly crystalline and amorphous Si for solar cells, Nano-micro Si-composite structure, various techniques of Si deposition.
UNIT - III MICRO FUEL CELL TECHNOLOGY

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

UNIT - V HYDROGEN STORAGE METHODS
Hydrogen storage methods - metal hydrides - size effects - hydrogen storage capacity - hydrogen reaction kinetics - carbon-free cycle - gravimetric and volumetric storage capacities - hydriding/dehydriding kinetics - high enthalpy of formation - and thermal management during the hydriding reaction.

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<th>NTE504</th>
<th>NANOSCALE MAGNETIC MATERIALS AND DEVICES</th>
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PURPOSE
To explore the relationship between the performance of magnetic devices and the microstructural characteristics of the materials from which they are constructed. Nanometer-sized magnetic particles feature a device-motivated approach that places strong emphasis on emerging technologies including magnetic data storage and spintronics.

INSTRUCTIONAL OBJECTIVES
1. To understand the basic magnetic parameters, and the importance of property-structure relations in determining the absolute value of these parameters
2. To understand the magneto-transport in nanoscale systems
3. To provide a knowledge of basic mechanisms for tuning the magnetic properties

UNIT - I INTRODUCTION

UNIT - II NANOMAGNETISM
UNIT - III  FABRICATION AND IMAGING

UNIT - IV  MAGNETIC DATA STORAGE AND RECORDING

UNIT - V  MAGNETIC STRUCTURES AND APPLICATIONS
Magnetic sensors and Giant Magnetoresistance - Optically transparent materials - Soft ferrites - Nanocomposite magnets - Magnetic refrigerator – High TC superconductor – Ferro/biofluids – Biomedical applications of magnetic nanoparticles - Diagnostic applications - Therapeutic applications - Physiological aspects - Toxic effects

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<th>NTE505</th>
<th>METALLOPOLYMER NANOCOMPOSITES</th>
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**PURPOSE**
The course presents and analyzes the essential data on nanoscale metal clusters dispersed in, or chemically bonded with polymers. The subject is mainly focused on the synthesis of the nanocomposites, their chemical interactions, and the size and distribution of the particles in the polymer matrix

**INSTRUCTIONAL OBJECTIVES**
1. To demonstrate the nano sized metal-containing particles in a polymeric matrix
2. To understand the methodology and specific methods of fabrication of hybrid polymer-inorganic nanocomposites
3. To know the mechanism of particle stabilization by polymeric surfactants

UNIT - I  NANOPARTICLES IN MATERIALS CHEMISTRY AND IN THE NATURAL SCIENCES
Classification of nanoparticles by size – Structural organization of nanoparticles – Dimensional phenomena in the chemistry and physics of nanoparticles – nanoparticles and materials on their base characteristic features of nanoparticles nucleation – Kinetic features of new phase formation – Phase formation in chemical reactions – Self organization of metal containing nanoparticles (Fractal structures) – Brief account of major production methods of metal containing nanoparticles – Metal clusters as nanoparticles with fixed dimensions

UNIT - II  PRINCIPLES AND MECHANISMS OF NANOPARTICLE STABILIZATION BY POLYMERS
Stability of nanoparticles in solutions – Stabilizing capability characteristics of polymers – Characteristics of polymer absorption on metal surfaces specifics of polymer surfactants as stabilizers – Mechanism of nanoparticles stabilization by polymers – Stabilization of nanoparticles by electrolytes – Surface proofing as a method of stabilizing nanoparticles by polymers on the problem of matrix confinement

UNIT - III  SYNTHETIC METHODS FOR METALLO-POLYMER
Nanocomposite preparation – Physical methods of incorporating nanoparticles into polymers – Mechanochemical dispersion of precursors jointly with polymers – Microencapsulation of nanoparticles into polymers – Physical deposition of metal nanoparticles on polymers – Formation of 2D nanostructures on polymers – Formation of metal
nanoparticles in polymer matrix voids (pores) – Physical modification and filling of polymers with metal reduction of polymer – Bound metal complexes – Nanocomposites formation by metal containing precursor thermolysis – Nanocomposite formation in monomer – Polymer matrices in thermolysis – Nanocomposites on the base of polymer – Immobilized metalloclusters

UNIT - IV PHYSICO-CHEMICAL METHODS FOR METALLO-POLYMER NANOCOMPOSITE PRODUCTION

UNIT - V NANOBIOCOMPOSITES
Basic notion of metal containing protein systems – Metal nanoparticles in Immunochemistry, Cytotoxicity and Medicine – Biosorption, selective heterocoagulation and bacterial concentration of metal nanoparticles – Sol-gel process as a way of template – Synthesized nanobioceramics – Biomineralization and bioinorganic nanocomposites – Control of physic-mechanical properties of nanocomposites – Peculiarity of nanocomposites synthesized by sol-gel methods – Polyolefin based nanocomposites – Polymer matrix structurization in nanocomposites – Physical and mechanical properties of metallopolymer nanocomposites – Nanocomposites in adhesion compounds and Tribopolymers – New trends in Material science connected with metallopolymeric nanocomposites

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<th>NTE506</th>
<th>NANOTOXICOLOGY</th>
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PURPOSE
To learn and understand social impact and health issues of environmental pollution caused due nanoindustries.

INSTRUCTIONAL OBJECTIVES
1. To provide knowledge on social impact of nanoindustry.
2. To design and conduct experiments, as well as to analyze the results.
3. To enhance the various analytical techniques and to identify and solve problems.
4. To understand the socio-ethical responsibility

UNIT - I POSSIBLE HEALTH IMPACT OF NANOMATERIALS
Sources of Nanoparticles: Epidemiological Evidence; Entry Routes into the Human Body – Lung, Intestinal Tract, Skin; Nano particle Size - Surface and Body Distribution; Effect of Size and Surface Charges; Nanoparticles, Thrombosis and Lung Inflammation ;Nanoparticles and Cellular Uptake; Nanoparticles and the Blood-Brain Barrier.

UNIT - II NANOMATERIALS FOR ENVIRONMENTAL REMEDIATION
UNIT - III  BIOTOXICITY OF METAL OXIDE NANOPARTICLES AND CARBON NANOTUBES
Introduction; Nanoparticles in the Environment; Nanoparticles in Mammalian Systems; Health Threats; Nanomaterials and Biototoxicity; Iron Oxide; Titanium Dioxide; Dark Studies; UV Irradiation Studies; Other Metal Oxides; Toxicological Studies and Toxicity of Manufactured CNTs - case study; Toxicity of CNTs and Occupational Exposure Risk; Toxicity of MWCNTs/SWCNTs and Impact on Environmental Health.

UNIT - IV  TOXICOLOGY OF NANOPARTICLES IN ENVIRONMENTAL POLLUTION
Air Pollution; Introduction to Air Pollution Particles; Adverse Effects of PM in Epidemiological Studies; Role of Nanoparticles in Mediating the Adverse Pulmonary Effects of PM; Effects of Nanoparticles on the Cardiovascular System; Nanoparticle Translocation and Direct Vascular Effects; Endothelial Dysfunction and Endogenous Fibrinolysis; Coagulation and Thrombosis; Cardiac Autonomic Dysfunction; Effects of Nanoparticles on the Liver and Gastrointestinal Tract; Effects of NP on the Nervous System.

UNIT - V  DOSIMETRY, EPIDEMIOLOGY AND TOXICOLOGY OF NANOPARTICLES
Epidemiological Evidence for Health Effect Associations with Ambient Particulate Matter; Toxicological Evidence for Ambient Particulate Matter Induced Adverse Health Effects; Inhaled Nanoparticle Dosimetry; Toxicological Plausibility of Health Effects Caused by Nanoparticles; Integrated Concept of Risk Assessment of Nanoparticles.

References:

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NTE507 GREEN MANUFACTURING TECHNOLOGY 3 0 0 3

PURPOSE
To motivate students to gain knowledge in the field of Green manufacturing technology

INSTRUCTIONAL OBJECTIVES
1. To make the students familiar with the field of traditional manufacturing to green manufacturing.
2. To familiarize with various processing of sustainable green manufacturing.
3. To familiarize with different types of waste management.
4. To develop the knowledge about the basic concepts of Industrial ecology.
5. To make students familiar with the importance of Green Plastics manufacturing.

UNIT - I  GREEN MANUFACTURING TRENDS
Green Manufacturing: Fundamentals and Applications - basic definitions and issues surrounding green manufacturing at the process, machine and system - government motivations for green manufacturing - traditional manufacturing to green manufacturing -economic issues- surrounding green manufacturing - the areas of automotive, semiconductor and medical areas as well as in the supply chain and packaging areas Green Manufacturing.

UNIT - II  SUSTAINABLE GREEN MANUFACTURING
UNIT - III  WASTE MANAGEMENT
Sustainability and global conditions - Material and solid waste management - Energy management - chemical waste management and green chemistry - Climate change and air emissions management - Supply water and waste water management - Environmental business management.

UNIT - IV  INDUSTRIAL ECOLOGY

UNIT - V  GREEN PLASTICS MANUFACTURING
Introduction to commercial plastics and elastomers -Natural Rubber (NR), modified NR and blends -Polymesters from microbial and plant biofactories (polylactic acid and polyhydroxyalkanoates) -Plastics from vegetable oils -Cellulose and starch based materials -Natural fillers, fibers, reinforcements and clay nanocomposites -Biodegradability, life cycle assessment and economics of using natural materials.

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<td>NTE508</td>
<td>ADVANCED CRYSTAL GROWTH TECHNIQUES</td>
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**PURPOSE**
The course brings together the science and technology of growing crystals, defect characterization and techniques, and understanding the defect formation including defects modelling.

**INSTRUCTIONAL OBJECTIVES**

1. To provide an experimental and theoretical contributions of crystal growth techniques including theory of nucleation and growth, molecular kinetics and transport phenomena
2. To understand the mechanism of crystal growth and to establish appropriate conditions for growing large defect-free crystals
3. To be familiar with the various growth parameters and their influence on the morphology and size control of crystals

UNIT - I  CRYSTAL GROWTH THEORY

UNIT - II  GROWTH FROM MELT

UNIT - III  GROWTH FROM VAPOR PHASE
Physical vapor deposition – Chemical vapor transport – Open and Closed system – Thermodynamics of chemical vapor deposition process – Physical and Thermo-chemical factors affecting growth process.
UNIT - IV GROWTH FROM SOLUTIONS

UNIT - V EPITAXY

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<th>NTE509</th>
<th>CARBON NANOTUBE ELECTRONICS AND DEVICES</th>
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PURPOSE
To provide the structural and electronic properties of carbon nanotubes, as well as the device structures and operation. It also deals with the incorporation of functionalized carbon nanotubes in field effect transistor, carbon nanotube device modeling and circuit simulation

INSTRUCTIONAL OBJECTIVES
1. To investigate the use of carbon nanotubes as active components in organic electronic devices
2. To explore the method of synthesis and its role in obtaining SWNT with desired characteristics
3. To understand the dependence of the performance of the nanotubes based transistors on the nanotube bundle geometry

UNIT - I BASICS OF CARBON NANOTUBES

UNIT - II SYNTHESIS AND INTEGRATION OF SWNT DEVICES

UNIT - III CARBON NANOTUBE FIELD-EFFECT TRANSISTORS

UNIT - IV AC RESPONSE AND DEVICE SIMULATION OF SWNT FETs
Assessing the AC response of Top gated SWNT FETs – Power measurement using a spectrum analyzer – Homodyne detection using SWNT FETs – RF characterization using a two tone measurement – AC gain from a SWNT FET common source amplifier – Device simulation of SWNT FETs – SWNT FET simulation using NEGF –
Device characteristics at the Ballistic limit – Role of Phonon scattering – High frequency performance limits – Optoelectronic phenomena.

UNIT - V  CARBON NANOTUBE DEVICE MODELING AND CIRCUIT SIMULATION

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<td>NTE510</td>
<td>NANO SCALE INTEGRATED COMPUTING</td>
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PURPOSE
Nanoscale integrated computing is an emerging technology with potential applications. The nanoscale architecture provides an increased computational speed, power-efficient, reduces the space requirements for interconnects and allows for fundamentally new computing paradigms.

INSTRUCTIONAL OBJECTIVES
1. To understand the evolution of computing technology and its significance
2. To understand the major advance in computing architectures involving “spin-wave buses”
3. To appreciate the computing architectures and algorithms in medical nanorobotics

UNIT - I  AN INTRODUCTION TO NANOCOMPUTING
Micro computing era – Transistor as a switch, difficulties with transistors at the nanometer scale – Nanoscale devices – Molecular devices – Nanotubes – Quantum dots – Wave computing – Quantum computing

UNIT - II  QUANTUM COMPUTING

UNIT - III  SPIN-WAVE ARCHITECTURES
Spin wave crossbar – Spin wave reconfigurable mesh – Spin wave fully interconnected cluster – Multi-scale Hierarchical architecture – Spin wave based logic devices – Logic functionality – Parallel computing with spin waves – Parallel algorithm design techniques – Parallel routing and broadcasting – On-Spin wave crossbar – On-Spin wave reconfigurable mesh – On-Spin wave fully interconnected cluster

UNIT - IV  MOLECULAR COMPUTING
Switching and memory in molecular bundles – molecular bundle switches – Circuit and architectures in molecular computing – Molecular grafting for silicon computing – Molecular grafting on intrinsic silicon nanowires – Self assembly of CNTs

UNIT - V  COMPUTATIONAL TASKS IN MEDICAL NANOROBOTICS
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<tr>
<th>NTE511</th>
<th>MICRO / NANO DEVICES AND SENSORS</th>
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**PURPOSE**
To have deeper understanding in fabrication of micro/nano devices and their architectures of sensing applications.

**INSTRUCTIONAL OBJECTIVES**
1. Demonstrate proficiency in the basic subfields of Engineering Physics as well as other areas of recent applications
2. Through critical thinking, problem solving in device designs of Micro-/Nano instruments
3. Construct and assemble experimental ideas, analyze available measurements of physical phenomena and their related things

**UNIT - I INTRODUCTION**
MEMS and NEMS definitions, Taxonomy of Nano-and Microsystems-Synthesis and Design. Classification and considerations, Biomimetics, Biological analogies, and design–Biomimetics Fundamentals, Biomimetics for NEMS and MEMS, Nano-ICs and Nanocomputer architectures.

**UNIT - II MODELING OF MICRO AND NANO SCALE ELECTROMECHANICAL SYSTEMS**
Introduction to modeling, analysis and simulation, basic electro-magnetic with application to MEMS and NEMS, modeling developments of micro-and nano actuators using electromagnetic-Lumped-parameter mathematical models of MEMS, energy conversion in NEMS and MEMS.

**UNIT - III INORGANIC AND ORGANIC ENABLED SENSORS**
Introduction-types of sensors-Mechanical, optical, spintronic, bioelectronic and biomagnetic sensors-surface modification-surface materials and interactions and its examples

**UNIT - IV SENSOR CHARACTERISTICS AND PHYSICAL EFFECTS**
Introduction to sensors, static Characteristics and dynamic characteristics, Physical effects : - Photoelectric Effect, Photoluminescence Effect, Electroluminescence Effect, Chemiluminescence Effect, Doppler Effect, Hall Effect, thermoelectric effect, magneto-optical phenomena

**UNIT - V FUTURE NANOSYSTEMS**
Nano machines, nano robots, electronics based on CNT, molecular Electronics. Quantum Computation: Future of Meso/Nanoelectronics? -Interfacing with the Brain, towards molecular medicine, Lab-on-BioChips- Guided evolution for challenges and the solutions in NanoManufacturing technology

References:
NTE512 SPECTROSCOPIC TECHNIQUES FOR NANOMATERIALS

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**PURPOSE**
To introduce to the students the basic principles of spectroscopy and to lay emphasis on advanced Spectroscopic techniques for Nanomaterials and the fundamentals

**INSTRUCTIONAL OBJECTIVES**

1. The objective of this course is to make the students acquire knowledge with the concepts of atomic and molecular spectra
2. The objective of this course is to make the students understand the principles underlying various spectroscopies and instrumentations specific to nanomaterials
3. The objective of this course is to make the students apply the laws, concepts and principles in problem solving and new formulations.

**UNIT - I NANO OPTICS**

**UNIT - II MOLECULAR SPECTROSCOPIES OF NANOASSEMBLIES**

**UNIT - III NONLINEAR SPECTROSCOPIES**
Absorption saturation and harmonic generation,Second-harmonic generation (SHG) and sum frequency spectroscopy (SFG)- Luminescence up conversion-The use of nonlinear optical methods to obtain infrared spectra of ultra-thin assemblies confined to surfaces.

**UNIT - IV LUMINESCENCE SPECTROSCOPY**
Optical properties of assembled nanostructures-interaction between nanoparticles-Direct and indirect gap transitions-, -Single molecule and single nanoparticles spectroscopy-Dynamic light scattering spectroscopy Fluorimetry and chemiluminescence - X-ray fluorescence spectrometry- Atomic emission spectroscopy.

**UNIT - V ELECTRON SPECTROSCOPIES FOR NANOMATERIALS**

**References:**
**PURPOSE**

To provide an adequate knowledge on various nanochemistry aspects.

**INSTRUCTIONAL OBJECTIVES**

1. To provide knowledge about chemistry based nanoprocess.
2. To design and conduct experiments relevant to nanochemistry, as well as to analyze the results.
3. To enhance the various nanosynthesis techniques and to identify and solve problems.
4. To improve usage of chemistry for modern technology.

**UNIT - I SIZE EFFECTS ON STRUCTURE AND MORPHOLOGY OF NANOPARTICLES**


**UNIT - II SUPERPLASTICITY AND REACTIVITY OF METAL nanoparticle**


**UNIT - III SUPRAMOLECULAR CHEMISTRY**

Supramolecular Chemistry: Applications and Prospects - From Molecular to Supramolecular Chemistry - Molecular Recognition - Anionic Coordination Chemistry and Recognition of Anionic Substrates - Multiple Recognition Applications and Prospects .

**UNIT - IV SUPERCRITICAL FLUIDS**


**UNIT - V FEATURES OF NANOSCALE GROWTH**


**References:**

UNIT - I  THIN FILM DEPOSITION TECHNIQUES

UNIT - II  CHARACTERIZATION TECHNIQUES

UNIT - III  ADSORPTION AND DIFFUSION IN THIN FILMS

UNIT - IV  STRESS IN THIN FILMS

UNIT - V  MODIFICATION OF SURFACES AND FILMS

References:

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<tr>
<th>NTE515</th>
<th>MICRO AND NANO EMULSIONS</th>
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PURPOSE
Emulsions are used in industry as components in a huge range of formulated products or as effect chemicals in the production or processing of other materials.

INSTRUCTIONAL OBJECTIVES
1. To define and identify emulsions and emulsifying agents
2. To understand the mechanism of emulsions and the process of stabilization
3. To provide basic knowledge on formulation and characterization of emulsions
UNIT - I INTRODUCTION
Definition of nano- and micro- emulsions – Reason for their long term kinetic stability – Practical application in personal care products and cosmetics, healthcare products, pharmaceuticals and agrochemicals – Schematic representation of oil/water and water/oil emulsions – Comparison with micelles and macroemulsions – Methods of emulsification: Pipe flow, static mixers and general stirrers, high-speed mixers, colloid mills and high pressure homogenizers – continuous and batch-wise preparations – turbulent flow.

UNIT - II MECHANISM OF EMULSIFICATION
Role of interfacial energy – Explanation of the high energy required for formation of nanoemulsions – The Laplace pressure concept – Role of surfactants: Reduction in interfacial tension and the effect on droplet size – Gibbs adsorption equation – Interfacial dilational modulus and droplet deformation – Interfacial tension gradients and the Marangoni effect - Solubilization theories: Concept of a duplex film and bending of the interface to form o/w or w/o emulsions – Phase diagrams of ternary systems of water, surfactant and cosurfactant – Concept of normal and inverse micelles – Quaternary phase diagrams of oil/water surfactant and cosurfactant – Solubilization of oil by nonionic surfactants

UNIT - III FORMULATION OF EMULSION

UNIT - IV CHARACTERIZATION OF EMULSIONS
Scattering techniques: Time average light scattering – Neutron scattering – Quasi-elastic light scattering (Photon Correlation Spectroscopy(PCS)) – Conductivity and NMR techniques: Conductivity of water/oil microemulsions, percolating and non-percolating emulsions, bicontinuous emulsions – Viscosity of emulsions – NMR technique for measurement of self diffusion of all components in emulsions and explanation of the various structures.

UNIT - V STABILITY OF EMULSION
Steric stabilization: Unfavourable mixing of the stabilizing chains – Entropic repulsion – Total energy – Distance curves for sterically stabilized emulsions – Variation of the energy curve with the ratio of adsorbed layer thickness to droplet radius – Thermodynamic stabilization: Reason for combining surfactant and cosurfactant to produce an ultra low interfacial tension – Formation of a model w/o emulsion using 4 steps – Relationship of droplet size to interfacial tension

References:
UNIT - I OVERVIEW

UNIT - II MARKET LANDSCAPE
Nanotechnology landscape and commercially attributable sectors - Tools to map, understand and segment the nanotechnology marketplace – Potential nanotechnology end-users and applications - Global market for nanotechnology products – Attracting venture capital – How to liaise effectively with partners - academy-industry relationship – University and employee’s inventions

UNIT - III COMMERCE AND REGULATION
Frameworks for developing nanotechnology marketplace – Incentives for Commercial applications – Shaping the Nanotech Marketplace- Allocating Costs associated with Risks – Public perception of nanotechnology – Critical impact of Regulation of Nanotechnology – Environment, health and safety within the nanotechnology industry—Developments that could influence the nanotechnology market – Impact for Future technologies

UNIT - IV BUSINESS STRUCTURES
Relationship b/w technology development and new business creation– the company concepts– new technology–new opportunity– sole proprietorships– general and limited partnerships– professional and closed corporations

UNIT - V MATERIALS PROCESSING ECONOMICS
Comparison and projection of yield– manufacturing output– labor and equipment expenses to calculate and estimate costs – relative performance enhancements for materials processing– alternate approaches– Identification of equipment– facilities and overheads – specific manufacturing methods– Tools to estimate the economics of process– Addressing the effect of overall system costs – its benefits

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<th>NTE517</th>
<th>NANOTECHNOLOGY INTELLECTUAL PROPERTY RIGHTS AND INNOVATION</th>
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PURPOSE
To overview the caveats concerning laws and its practices, and other governing principles related to the technological development and its protected principles

INSTRUCTIONAL OBJECTIVES
1. To provide the international/national visibilities of nano-science developments and their relevance in multi-functionalities
2. To meet the substantial requirements of innovation communities by providing the valid models and assessments
3. To further understand the role of societal and ethical implications and their trends

UNIT - I BACKGROUND
Introduction: the invisible infrastructure of innovation-Intellectual Property Dynamics in Society- The types of Intellectual Property- Patent documents-the construction of the patent, face of the patent, conception, body of
UNIT - II BASICS OF MANAGING INTELLECTUAL PROPERTY IN ORGANIZATIONS
The innovation forest: intellectual property rights and how they grow- The ABCDs of intellectual property: flow and infringement of IP rights-the patent system - copyrights- trademarks-trade secrets- The global diversity of innovation communities-The role of the innovation chief.

UNIT - III NANOTECHNOLOGY POLICY AND REGULATION
Understanding Nanotechnology- the industrial structure giving rise to Nanotechnology- Societal and Ethical Implications-Environmental Regulation - National Security and Export Controls- Federal Funding-Conclusions

UNIT - IV THE ECONOMIC AND LEGAL FOUNDATIONS

UNIT - V STRATEGIC MANAGEMENT OF INTELLECTUAL PROPERTY
A menu of strategy options,- Evaluating internal resources and the external environment – Placing a financial value on IP assets - Accessing innovations of others - Protecting and enforcing IP rights- Transferring IP rights -Strategies on a Global Stage- Specific IP strategies for different communities- Global challenges

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<th>NTE518</th>
<th>NANO – CMOS CIRCUITS AND PHYSICAL DESIGNS</th>
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PURPOSE
To introduce to the students the basic principles of Nano-CMOS Circuit and Physical Design

INSTRUCTIONAL OBJECTIVES
1. To make the students acquainted with the concepts of CMOS scaling
2. To describe the practicilities of sub wavelength lithography
3. To focus on signal integrity problems

UNIT - I NANO-CMOS SCALING PROBLEMS AND IMPLICATIONS

UNIT - II PRACTICALITIES OF SUBWAVELENGTH OPTICAL LITHOGRAPHY
Simple Imaging Theory – Challenges for the 100-nm Node – e-Factor for the 100-nm Node – Corner Rounding Radius – Resolution Enhancement Techniques: Specialized Illumination Patterns – Optical Proximity Corrections – Subresolution Assist Features – Alternating Phase-Shift Masks – Physical Design Style Impact on RET and OPC
Complexity – Specialized Illumination Conditions – Two-Dimensional Layouts – Alternating Phase-Shift Masks – Mask Costs

UNIT - III PROCESS SCALING IMPACT ON DESIGN MIXED-SIGNAL CIRCUIT DESIGN

UNIT - IV ELECTROSTATIC DISCHARGE PROTECTION DESIGN

UNIT - V SIGNAL INTEGRITY PROBLEMS IN ON-CHIP INTERCONNECTS

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<th>NTF501</th>
<th>APPLIED OPTICS</th>
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PURPOSE
The course provides basic introduction to the field of applied optics and then develops this theme to illustrate the many diverse applications of optical technology.

INSTRUCTIONAL OBJECTIVES
1. To explain the basic underlying physical principles of optics, optical phenomena and optical equipment
2. To introduce and illustrate a range of optical instruments and techniques including geometrical and physicaloptics, thin film devices, interferometry and holography
3. To provide introduction to the techniques involved in designing optical systems

UNIT - I LIGHT SOURCES, GEOMETRIC OPTICS AND ABERRATION

UNIT - II ABERRATIONS AND OPTICAL SYSTEMS
Wave and Ray aberration - Spherical aberration – Chromatic aberration - Siedel aberrations - Simple Optical systems and Photographic lens - Characteristics of Objective lenses, Eyepieces, Condensers for different
applications – Microscopes, Telescopes – Human eye and Opthalmic Lens – Types of Prism systems and Image manipulation

UNIT - III  THIN FILM OPTICS
Propagation of electromagnetic waves in layered media – Metallic and Interference coatings –Anti-reflection coatings – High reflectance mirrors – Band-pass filters – Polarising beam splitters – Narrow band interference filters

UNIT - IV  DIFFRACTIVE AND HOLOGRAPHIC OPTICS
Differences between holographic and lens imaging – Transmission and Reflection gratings – Diffraction efficiency – Basic Holographic Recording and Analysis – Diffraction pattern and Hologram Image analysis – Holographic materials (recent developments)

UNIT - V  OPTICAL INTERFEROMETRY, MICROSCOPY AND METROLOGY

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<th>NTF502</th>
<th>NANOPOLLUTION AND e-WASTE MANAGEMENT</th>
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**PURPOSE**
To learn and understand social impact of environmental pollution caused due nanoindustries.

**INSTRUCTIONAL OBJECTIVES**
1. To provide knowledge on social impact of nanoindustry.
2. To design and conduct experiments, as well as to analyze the results.
3. To enhance the various analytical techniques and to identify and solve problems.
4. To understand the socio-ethical responsibility

UNIT - I  ANALYSES OF NANOPARTICLES IN THE ENVIRONMENT

UNIT - II  ENVIRONMENTAL FATE AND TRANSPORT.
Nature of Nanomaterials in the Environment - Physical Manifestation of Nanomaterials: Particle SizeDistribution and Formation of Mobile Suspensions - Chemical Forces Acting on Nanomaterials - Electrostatic or Coulomb

UNIT - III POTENTIAL ECOLOGICAL HAZARDS OF NANOMATERIALS

UNIT - IV E-WASTE MANAGEMENT

UNIT - V INTEGRATED APPROACH TO E-WASTE RECYCLING

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<th>NANOSCOPIC TOOLS AND TECHNIQUES</th>
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PURPOSE
To provide an overview of contemporary spectroscopy, microscopy, diffraction and analysis tools to characterize different properties of nanomaterials.

INSTRUCTIONAL OBJECTIVES
1. To develop ability to understand modern characterization techniques especially utilized to probe in nanoscopic regime
2. To elucidate on application of standard spectroscopy, microscopy techniques for element analysis, structure analysis, depth profiling, topography imaging, as well as surface and interface analysis
3. To provide overview of principles underlying the characterization methods and basic theory for analysis of the data obtained from the instrument

UNIT - I MICROSCOPY TOOLS
Optical microscopy - Scanning Electron microscopy (SEM) - Energy dispersive X-ray microanalysis (EDS) - Transmission Electron microscopy (TEM) - Atomic Force microscopy (AFM) and related scanning probe microscopy (SPM) - Scanning Tunneling microscopy (STM)
UNIT - II OPTICAL SPECTROSCOPY
UV-visible electronic absorption spectroscopy – Fourier transform infrared spectroscopy (FTIR) – Photoluminescence spectroscopy - Electro-luminescence spectroscopy - Raman Ellipsometry – X-ray Photoelectron spectroscopy

UNIT - III STRUCTURE AND MORPHOLOGY ANALYSIS TOOLS

UNIT - IV CHEMICAL AND THERMAL ANALYSIS TECHNIQUES
Raman spectroscopy - Infrared spectroscopy – Nuclear Magnetic Resonance (NMR) - Surface-enhanced Raman Scattering for Single Nanoparticle and Single Molecule – Dynamic Light Scattering for Nanoparticle assembly - Differential Thermal analysis (DTA) - Differential Scanning Calorimetry (DSC) - Thermogravimetric analysis (TGA)

UNIT - V ELECTRICAL AND MAGNETIC CHARACTERIZATION TECHNIQUES

References: