LIST OF SUBJECTS

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<td>Introduction to Nanostructured Materials</td>
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<td>NT302</td>
<td>Synthetic Methodologies for Nanomaterials</td>
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<td>NT315</td>
<td>Chemical Principles of Self Assembly Systems</td>
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<td>Nanosensors and Transducers</td>
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<td>Industrial Nanotechnology</td>
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<td>NT319</td>
<td>Molecular Photonics</td>
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NT301 INTRODUCTION TO NANOSTRUCTURED MATERIALS

Credit 4:0:0

Unit I - Introductory Aspects

Unit II - Bulk Nanostructured Materials
Solid disordered Nanostructures – Nanostructured crystals – Nanostructured Ferromagnetism; optical and vibrational spectroscopy; Infrared frequency range – Luminescence – Quantum wells, wires and Dots – Size ad dimensionality effects – Excitons – Single electron tunneling – Applications – Superconductivity; Self assembly and catalysis

Unit III - General Characterization Techniques


**Unit IV - Luminescence of Semiconducting Nanoparticles**
Fluorescence of semiconducting nanoparticles – Photoluminescence of doped semiconductor nanoparticles – Shift in photoluminescence peaks - Electro luminescence – Nanoparticle LED – Thermo luminescence – Cathode luminescence – Magneto luminescence

**Unit – V - Nano Devices**
Background – Quantization of resistance - Single electron transistors – Esaki and resonant tunneling diodes – Magnetic Nanodevices – Magnetoresistance – Spintronics – MEMS and NEMS

**Reference Books**
1. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley, 2003
3. Introduction to Solid State Physics, C. Kittel, a chapter about Nanotechnology, Wiley, 2004

**NT302 SYNTHETIC METHODOLOGIES FOR NANOMATERIALS**

**Credit 4:0:0**

**Unit I - Chemical methods**

**Unit II - Carbon and related materials**

**Unit III - Mechanical methods**
Grinding – high energy ball milling – types of balls – WC and ZrO2 – material-ball ratio – medium for grinding – limitations in getting required grain size for low melting point materials – typical systems – severe plastic deformation – melt quenching and annealing

**Unit IV - Ultra high vacuum system**

**Unit V - Nanopolymers**

Nanopolymers – Preparation and characterization of diblock Copolymer based nanocomposites, Nanoparticles polymer ensembles; Assembly of polymer – Nanoparticles composite material; Fabrication of polymer-mediated organized Nanoparticles assemblies; Applications of Nanopolymers in Catalysis.

**Reference Books**

1. Vacuum Technology & Coating, 2000, Cowan & Co

**NT303 BIOLOGY FOR NANOTECHNOLOGY**

**Credit 4:0:0**

**Unit I**

Structure and organization of prokaryotic and eukaryotic cell (Animal cell & plant cell), tissues and organs, Cell and Tissue Culture – Application of plant Transformation for Productivity and performance - Green House and Green House Technology. Animal Cell Culture Technology – Applications of Animal Cell Culture-Stem Cell Culture, Artificial organ synthesis,

**Unit II**


**Unit III**

Unit IV
Basic Immunology and immune system – Antigen, antibody structure and its types, humoral immunity, Cell mediated immunity, introduction, to complement system- MHC & graft transplantation and graft rejection.

Unit V
Biosynthesis of Nanoparticles, Microbial Nanoparticle production Biomineralization, Magnetosomes, Nanoscale magnetic iron minerals in bacteria, virus & fungi. DNA based Nano structures. Protein based Nano structures.

Reference Books
4. Foster C.F. John ware D.A. Environmental Biotechnology, Ellis, Honwood Ltd. 1987
9. Gunter Schmid (Ed), Nano Particles, Jhon wiley and sons limited, 2004
11. "From Genes to Clones" by Ernat-L.Winnacker, Panima Publishing Corporation, India, 2003
12. "Biotechnology : Fundamentals and Applications" by S.S. Purohit, Agrobios(Ind), Jodhpur, 2002
15. Elsevier, Amsterdam

NT304 ENGINEERING PRINCIPLES FOR NANOTECHNOLOGY

Credit 4:0:0
Unit I - Thin Film Technology
Electro plating, Electroless plating, Langmuir-Blodget films, Thermal growth, Chemical vapour deposition, sputtering deposition, molecular beam epitaxy atomistic nucleation process, cluster coalescence and deposition, grain structure of films and coatings, amorphous thin films.

Unit II - Analysis of Thin films
Mechanical, electrical, magnetic and optical properties of Thin film, Analysis of thin films.

Unit III - Vacuumed Technology
Pump selection and exhaust handling, rotary oil pumps, roots pump, diffusion pumps, turbo molecular pump, cryo pump, sputter-ion pump, pressure measurements, thermodynamics of evaporation, evaporation rate, alloys, compounds, sources, transport and deposition monitoring.

Unit IV - MEMS

Unit V - Silicon Technology
Semiconductor as base material- band diagram of semiconductor- band diagram of inhomogeneous semiconductor- different types of components in semiconductor, different types of transistor integration- technological processes for microminiaturization- methods and limits of microminiaturization in silicon.

Reference Books

NT305 SYNTHESIS OF NANOMATERIALS
Credit 0:0:4
12 experiments will be notified by the HOD from time to time

NT306 FABRICATION AND IMAGING TECHNIQUES FOR NANOTECHNOLOGY
Credit: 4:0:0
Unit I
Si processing methods – Cleaning/etching – Oxidation-oxides – Gettering – doping – Epitaxy. Top-down techniques – Photolithography – Other optical lithography’s (EUV, X-ray, LIL) – Particle beam lithographies (e-beam, FIB, shadow mask evaporation) – Probe lithography’s. Processing of III-V semiconductors including nitrides

Unit II
Molecular-beam epitaxy – Chemical beam epitaxy – Metal-organic CVD (MOCVD) – Bottom-up techniques – Self-assembly – Self-assembled monolayers – Directed assembly – Layer-by-layer assembly – Combinations of top-down and bottom-up techniques – Current state of the art

Unit III

Unit IV

Unit V

Reference books
2. Richard Xylen, “Physics of Amorphous Solids”
NT307 THERMODYNAMICS AND QUANTUM MECHANICS FOR NANO SCALE SYSTEMS

Credit 4:0:0

Unit I - Review of the Laws of Thermodynamics and their Consequences

Unit II - Statistical Description of Systems of Particles

Unit III - Quantum mechanics
Quantum Mechanics -Review of classical mechanics -de Broglie's hypothesis -Heisenberg uncertainty principle -Pauli exclusion principle -Schrödinger's equation -Properties of the wave function -Application: quantum well, wire, dot -Quantum cryptography

Unit IV - Electrical and magnetic properties
Electronic and electrical properties-One dimensional systems-Metallic nanowires and quantum conductance - dependence on chirality -Quantum dots -Two dimensional systems - Quantum wells and modulation doping -Resonant tunnelling -4.Magnetic properties Transport in a magnetic field -Quantum Hall effect. -Spin valves -Spin-tunnelling junctions - Domain pinning at constricted geometries -Magnetic vortices

Unit V - Mechanical and Optical Properties
Mechanical properties -Individual nanostructures - Bulk nanostructured materials-Ways of measuring-Optical properties-Two dimensional systems (quantum wells)-Absorption spectra -Excitons -Coupled wells and superlattices - Quantum confined Stark effect

Reference Books
1. Fundamentals of Statistical and Thermal Physics – Federick Reif.
2. Statistical Mechanics – Bipin K. Agarwal and Melvin Einsner
6. Introduction to Solid State Physics, C. Kittel, a chapter about Nanotechnology, Wiley, 2004

**NT308 NANOBIO TECHNOLOGY**

**Credit 4:0:0**

**Unit – I**
Biology inspired concepts – biological networks-biological neurons - the function of neuronal cell- biological neuronal cells on silicon modelling of neuronal cells by NLSI circuits – bioelectronics- molecular processor – DNA analyzer as biochip – molecular electronics

**Unit – II**
Nano biometrics – Introduction – lipids as nanobricks and mortar: self assembled nanolayers-the bits that do think – proteins- three dimensional structures using a 20 aminoacid-biological computing – a protein based 3D optical memory using DNA to build nano cubes and hinges – DNA as smart glue – DNA as wire template – DNA computers

**Unit – III**
Natural Nanocomposites – Introduction – natural nano composite materials- biologically synthesized nanostructures- biologically derived synthetic nanocomposites- protein based nanostructure formation – biologically inspired nanocomposites – nanotechnology in Agriculture (Fertilizers and pesticides)

**Unit – IV**

**Unit – V**

**Reference Books**
5. Protein Nanotechnology Protocols, Instrumentation and Application, Tuan Vo-Dinh, Series ; Methods in Molecular Biology (2005)

NT309 NANOELECTRONICS

Credit 4:0:0

Unit I
Basics of nanoelectronics – capabilities of nano electronics – physical fundamentals of nano electronics – basics of information theory – the tools for micro and nano fabrication – basics of lithographic techniques for nanoelectronics

Unit II

Unit III

Unit IV

Unit V

Reference Books
1. Nanoelectronics and Nanosystems, Karl Goser, Peter Glosekotter, Jan Dienstuhl., Springer, 2004

NT310 ADVANCED EXPERIMENTS AND SIMULATION TECHNIQUES FOR NANOPARTICLE CHARACTERIZATION

Credit 0:0: 4

12 experiments will be notified by the HOD from time to time

NT311 NANOLITHOGRAPHY

Credit 4:0:0

Unit I

Unit II

Unit III

Unit IV

Unit V

Reference Books

NT312 NANOTECHNOLOGY FOR ADVANCED DRUG DELIVERY SYSTEMS

Department of Nanotechnology
Credit : 4:0:0

Unit I : Principles of drug delivery systems: modes of drug delivery, ADME hypothesis – controlled drug delivery, site specific drugs, barriers for drug targeting, passive and active targeting. Strategies for site specific, time and rate controlled delivery of drugs, antibody-based and metabolism-based targeting

Unit II : Targetted Nanoparticles for drug delivery: Nanoparticles surface modification, bioconjugation, pegylation, antibodies, cell-specific targeting and controlled drug release, Multi-Functional Gold Nanoparticles for Drug Delivery: Virus Based-nanoparticles

Unit III : Dendrimers as Nanoparticular Drug Carriers: – Synthesis – Nanoscale containers — Naoscafold systems – Gene transfection, Biocompatibility Polymer Micelles as Drug Carriers, Polymers nanotubes- Magnetic Nanoparticles as Drug Carriers

Unit IV : Liposomes for drug delivery and targeting: classification and preparation of liposomal nanoparticles. Liposomes for pharmaceutical and cosmetic applications, Liposomal Drug Carriers in Cancer Therapy, lipid-DNA complexes, viral gene transfection systems, Lipid based drug delivery systems for peptide and protein drug delivery, Liposomal anticancer and antifungal agents

Unit V : Nanoparticle and targeted systems for cancer diagnosis and therapy: Targeted delivery through enhanced permeability and retention. Folate receptors, Targeting through angiogenesis, Targeting to specific organs or tumor types, Tumor-specific targeting: Breast cancer, Liver, Targeting tumor vasculature for Imaging, Delivery of specific anticancer agents: such as Paclitaxel, Doxorubicin, 5-Fluorouracil etc

References

NT313 EXPERIMENTAL TECHNIQUES FOR NANOBIO TECHNOLOGY

Credit 0:0:4

12 experiments will be notified by the HOD from time to time
NT314 NANO BIOMATERIALS

Credit 4:0:0

Unit I
Polymeric implant materials: Polyolefin; polyamides (nylon); Acrylic polymers (bone cement) and hydrogels; Fluorocarbon polymers; Natural and synthetic rubbers, silicone rubbers; High strength thermoplastics; Deterioration of polymers - applications of nano biomaterial

Unit II

Unit III
Cardiovascular implants: Role of nanoparticles and nanodevices in Blood clotting; Blood rheology; Blood vessels; Geometry of blood circulation; Vascular implants; Cardiac pacemakers; Blood substitutes; Biomembranes.

Unit IV

Unit V

Reference Books
4. Nanofabrication towards biomedical applications wiley –VCHVerlag GmbH & CO, KGaA.
5. Robert W. Kelsall, Ian W. Hamley, Mark Geoghegan (Ed), Nano Scale Science And Technology, John Wiley and son, ltd., 2005
NT315 CHEMICAL PRINCIPLES OF SELF-ASSEMBLY SYSTEMS

Credit 4:0:0

Unit I - Fundamentals of Self-assembly and Nanochemistry

Unit II - Monolayer self-assembly

Unit III - Layer-by-layer self-assembly

Unit IV - Nanocluster self-assembly

Unit V - Bio-inspiration in nanochemistry

Reference Books
2. Core Concepts on Supramolecular Chemistry and Nanochemistry, Jonathan Steed and Jerry Atwood
4. The Physics and Chemistry of Nanosolids, Frank J.Owens and Charles P.Poole Jr., Wiley Interscience Publishers
5. Encyclopedia of Nanochemistry, R.Thomson, Anmol Publishers

NT316 NANOSENSORS AND TRANSDUCERS
Credit:4:0:0

Unit I : Transducers

Unit II : Sensor Characteristics and Physical effects:

Unit III: Nano based Inorganic sensors

Unit IV : Organic / Biosensors
Unit V: Signal conditioning and data acquisition

Reference Books

NT317 INDUSTRIAL NANOTECHNOLOGY

Credit 4:0:0

Unit I - Overview of Information Storage and Nanotechnology
Different types of information storage materials and devices: solid state memory, optical memory, magnetic recording, emerging technologies, role of nanotechnology in data storage.

Unit II - Optical Data Storage
Write and read techniques (signal modulation, disk format, data reproduction), read and write principles (read-only, write-once, phase-change, magnetooptic disks), optical pickup heads (key components, diffraction-limited laser spot, focusing and tracking error signals, servo-loop design, actuator), optical media, near field optical recording, holographic data storage.

Unit III – Energy Devices
Solar cells - Thin film Si solar cells - Chemical semiconductor solar cells - Dye sensitized solar cells - Polymer solar cells - Nano quantum dot solar cells - Hybrid nano-polymer solar cells


Unit IV – Nano pharmaceuticals
Unit V - Industrial applications of nanomaterials

Reference Books
5. A. A. Balandin, K. L. Wang “Handbook of Semiconductor Nanostructures and Nanodevices” Vol 1-5
13. Dr.Parag Diwan And Ashish Bharadwaj, Nano Electronics, Pentagen press, 2006

NT318 NANOCOMPOSITES

Credit 4:0:0

Unit I - Introduction of nanocomposites

Unit II - Properties and features of nanocomposites
Unit III - Processing of nanocomposites
Viscosity - Types of flow – Viscosity - Experimental viscosity - Non-newtonian flow - Low-viscosity processing - Solvent processing - Particle behavior - In situ polymerization - Post-Forming - Hazards of solvent processing - Melt, high-shear, and direct processing - Melting and softening - Melt processes with small shears or low-shear rates flow - Melt processes with large deformations or high-shear rates - Thermo-kinetic processes

Unit IV - Characterization of nanocomposites

Unit V: Applications of nanocomposites
Nanocomposites – Optical, structural applications – Nanoparticulate systems with organic matrices – Applications – Biodegradable protein nanocomposites - Applications Polypropylene nanocomposites – Application as exterior automatic components – Hybrid nanocomposite materials – Application for corrosion protection

Reference books
4. Ray Smith, Biodegradable polymers for Industrial Applications, CRC Press, 2005

NT319 MOLECULAR PHOTONICS
Credit 4:0:0

Unit I - Concept of Polarization
Molecule/material interaction with electromagnetic waves as described by Maxwell equations. Wave optics, ray optics, beam optics, polarization, Snell laws and lens formula, Lambert-Beer law, excited states and molecular orbitals, the influence of π-electron system expansion on the absorption spectrum, the Jablonski diagram

Unit II - Fundamentals of Fluorescence
Excited states, fluorescence and phosphorescence, emission yield, polarization, lifetime, quenching. **Applications** - molecular orientation and dynamics studied by energy transfer and quenching; Stern-Volmer model, FRET, Dexter and Förster mechanisms, excitonic interaction, J and H aggregates

**Unit III - Experimental Methods of Fluorescence Spectroscopy**
Biological fluorophores and molecular probes, steady-state emission and excitation spectra, time-correlated single photon counting, up-conversion, **Light Scattering** - determining molecular size and characterizing intermolecular interactions from Rayleigh scattering data, explaining Raman effect

**Unit IV- Nonlinear Optical Effects**
Second-order and third-order, electrooptics (Mach-Zehnder switch), photo refractivity, Two Photon Absorption and Optical Switching - physical description, applications in TP fluorescence spectroscopy and optical computing, study of Surfaces and Interfaces 2nd harmonics at surfaces, 3rd and higher order methods to study dynamics, photon echoes, optical Kerr effect

**Unit V - Electron Transfer**
Marcus model and applications to molecular systems- Photoconductivity and Photovoltaics inorganic nanocrystalline solar cells, organic polymer photoconductors, electroluminescencent materials. **Photochemistry** - photoisomerization, photoacids, photochromism] Photons as Medicine and Diagnostics Tools-singlet oxygen photochemistry, photodynamic therapy, tetrapyrroroles as photosensitizes for PDT, measuring tissue oxygenation, optical tomography

**Reference Books**
1. K. Horie, H. Ushiki, F. M. Winnik, Molecular Photonics, 2000, Wiley VCH.
ADDITIONAL SUBJECTS

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<tr>
<th>Code</th>
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<td>Introduction to Nanostructured Materials</td>
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<td>Biology for Nanotechnology</td>
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<tr>
<td>09NT325</td>
<td>Nano Toxicology</td>
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09NT320 - INTRODUCTION TO NANOSTRUCTURED MATERIALS
Credit 4:0:0

Objectives:

1. To acquire the fundamental knowledge about nanostructured materials
2. To understand about the characterization techniques used for characterizing nanomaterials
3. To understand the theory of luminescence of semiconducting nanoparticles
4. To acquire the basic understanding about nanodevices

UNIT I: INTRODUCTORY ASPECTS
Free electron theory and its features, Idea of band structure – Metals, Insulators and Semiconductors - Density of state in bands and its variation with energy, Effect of crystal size on density of states and band gap – Electronic structure of nanoparticles

UNIT II: BULK NANOSTRUCTURED MATERIALS
Solid disordered Nanostructures – Nanostructured crystals – Luminescence – Quantum wells, wires and Dots – Size and dimensionality effects – Excitons – Superconductivity; Self assembly and catalysis

UNIT III: GENERAL CHARACTERIZATION TECHNIQUES
UV – Vis- IR - absorption Spectroscopy, X- Ray Diffraction studies –Bragg’s law – particle size – Scherrer’s equation, –FT-IR – FT- Raman studies - Surface Resonance

UNIT IV: LUMINESCENCE OF SEMICONDUCTING NANOPARTICLES
Theory of photoluminescence, Fluorescence of semiconducting nanoparticles – Photoluminescence of doped semiconductor nanoparticles – Shift in photo luminescence peaks - Electroluminescence– Thermo luminescence –Cathode luminescence – Magneto luminescence
UNIT – V: NANO DEVICES
Background – Quantization of resistance - Single electron transistors – Esaki and resonant tunneling diodes – Magnetic Nanodevices – Magneto resistance – Spintronics

Reference Books

09NT321 - BIOLOGY FOR NANOTECHNOLOGY

Credit 4:0:0

Objectives:
1. To acquire the basic knowledge about animal and plant cells
2. To understand about molecular targets
3. To know the chemistry of genetic engineering
4. To understand the concept of biosynthesis of nanoparticles

Unit I
Structure and organization of prokaryotic and eukaryotic cell (Animal cell & plant cell), tissues and organs, Cell and Tissue Culture – Application of plant Transformation for Productivity and performance - Animal Cell Culture Technology – Applications of Animal Cell Culture-Stem Cell Culture, Artificial organ synthesis,

Unit II

Unit III

Unit IV
Cells and organs of immunity, Types of Innate and acquired immune system – Antigen, antibody structure and its types, humoral immunity, Cell mediated immunity, introduction, to complement system- MHC & graft transplantation and graft rejection.
Unit V
Biosynthesis of Nanoparticles, Microbial Nanoparticle production Biomineralization, Magnetosomes, Nanoscale magnetic iron minerals in bacteria, virus & fungi. DNA based Nano structures. Protein based Nano structures.

Reference Books
2. K. K. Jain, ‘Nanobiotechnology Molecular Diagnostics: Current Techniques and Applications (Horizon Bioscience)’, Taylor & Francis, 2006

09NT322 - FABRICATION AND IMAGING TECHNIQUES FOR NANOTECHNOLOGY

Credit 4:0:0

Objectives:

1. To acquire knowledge about general nanofabrication techniques
2. To understand the concepts of spectroscopy techniques
3. To know the mechanical methods of characterizing nanomaterials
4. To study the x-ray related techniques used for characterizing the nanomaterials

Unit I: General Fabrication Techniques
Key challenges and barriers for nanocharacterization - Photolithography – Cleaning / etching – Oxidation - oxides – Gettering – doping – Epitaxy. Top-down techniques – Other optical lithographies (EUV, X-ray, LIL) – Particle beam lithographies (e-beam, FIB, shadow mask evaporation) – Probe lithographies. – Ball milling – Chemical routes – Chemical Vapour Deposition, wet chemical routes

Unit II: Spectroscopic techniques
Spectroscopy of Semiconductors – excitons – Brillouin spectroscopy – Dynamic Light Scattering (DLS) – NMR Spectroscopy – ESR Spectroscopy – X-ray photo electron spectroscopy (XPS) - electron spectroscopy for chemical Analysis (ESCA) - Principles and applications of the above methods

Unit III: Probing techniques and magnetometry
Scanning electron microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Tunneling Microscopy (STM), Atomic force microscopy (AFM), Near field optical scanning microscopy (NSOM) - Vibrating sample magnetometry (VSM)
Unit IV: Mechanical characterization

Unit V: Neutron and X-ray diffraction and crystallography

Reference Books

**09NT323 - NANOBIO TECHNOLOGY**

Credit: 4:0:0

Objectives:

1. To acquire knowledge about biochips and molecular electronics
2. To understand the concepts of biological computing techniques
3. To know the fundamentals about natural nanocomposites
4. To know about molecular manufacturing and nano simulation techniques

Unit: I
Biology inspired concepts-biological networks-biological neurons-the function of neuronal cell-biological neuronal cells on silicon modeling of neuronal cells by NLSI circuits-bioelectronics-molecular processor-DNA analyzer as biochip-molecular electronics.

Unit: II
Nanobiomectrics - introduction-lipids as nanobricks and mortar, self assembled nanolayers-the bits that do think-proteins-three dimensional structures using a 20 aminoacid-biological computing-a protein based 3D optical memory using DNA to build nano cubes and hinges-DNA as smart glue-DNA as wire template-DNA computers.
Unit: III
Natural nanocomposites-introduction-natural nano composite materials-biologically synthesized nanostructures-biologically derived synthetic nanocomposites-protein based nanostructure formation-biologically inspired nanocomposites-nanotechnology in Agriculture [Fertilizers and Pesticides].

Unit: IV
Nano analytics-quantum dot biolabeling-nanoparticle molecular labels-analysis of biomolecular structure by AFM and molecular pulling-force spectroscopy-biofunctionalized nanoparticles for surface enhanced raman scattering and surface Plasmon resonance.

Unit: V
Molecular Manufacturing-Nano simulation, implications of nanotechnology, health and safety implications from nanoparticles. Health issues-Environmental issues-need for regulation-social implications, possible military applications-potential benefits and risks for developing countries-studies on the implications of nanotechnology.

Reference Books

09NT324 - NANO BIOMATERIALS

Credit 4:0:0

Objectives:
1. To acquire knowledge about polymeric implant materials
2. To know the role of biomaterials for implant coating
3. To understand the concepts of cardiovascular implants
4. To know the basics of biopolymers and tissue engineering

Unit I
Polymeric implant materials: Classification of biomaterials, Polyolefin; polyamides (nylon); Acrylic polymers (bone cement) and hydrogels; Fluorocarbon polymers; Natural and synthetic rubbers, silicone rubbers.

Unit II
Bio materials for implant coating: calcium phosphates, Ti_{6}Al_{4}V and biomedical alloys - implant tissue interfacing -biomimetic and solution based processing – osteo porosis – osteo plaste – regeneration of bones by using bio compactable ceramics – biointeractive hydro gels.
Unit III
Cardiovascular implants: Role of nanoparticles and nanodevices in Blood clotting; Blood rheology; Blood vessels; Geometry of blood circulation; Vascular implants; Cardiac pacemakers; Blood substitutes; Biomembranes, Ophthalmological applications of nano biomaterial.

Unit IV

Unit V

Reference Books
2. Robert W. Kelsall and Ian W. Hamley, Mark Geoghegan, Nano Scale Science and Technology, John Wiley, 2005
5. K. K. Jain, ‘Nanobiotechnology Molecular Diagnostics: Current Techniques and Applications (Horizon Bioscience)’, Taylor & Francis, 2006

09NT325 - NANO TOXICOLOGY

Credit 4:0:0

Objectives:
1. To acquire the basic knowledge about nanotoxicology
2. To know the mechanism of nanosized particle toxicity
3. To know about nanopollution
4. To understand the human exposure to nanosized materials and risk assessment

Unit I: Introduction
Concept of Nanotoxicology - Laboratory rodent studies - Ecotoxicologic studies - Methodology for Nanotoxicology - toxicity testing

Unit II: Mechanism
Mechanism of nanosize particle toxicity - Reactive oxygen species mechanisms of NSP toxicity - Interactions between Nanoparticles and Living Organisms: Mechanisms and Health Effects - Interactions of Nanoparticles with Cells and their Cellular Nanotoxicology - Cytotoxicity of Ultrafine Particles - Cytotoxicity and Potential Mechanism of Nanomaterials

Unit III: Pollution
Nanopollution – Nanomaterials in Environment - Toxicology of Airborne - Manufactured nanomaterials in the environment

Unit IV: Human exposure to Nanosized Materials
Biological Activities of Nanomaterials and Nanoparticles - Respiratory Tract - Efficient deposition of inhaled NSPs. - Disposition of NSPs in the respiratory - Disposition of NSPs in the respiratory - Epithelial translocation - Translocation to the circulatory system - Neuronal uptake and translocation - Translocation of NSPs in the blood circulation to bone marrow in mice - Studies of neuronal translocation of UFPs from respiratory tract - Exposure via GI Tract and Skin

Unit V: Risk Assessment and Execution

Reference Books
3. Gunter Oberdörster, Eva Oberdorster and Jan Oberdorster, Environmental Health Perspectives, Volume 113 Number 7, July 2005
DEPARTMENT OF NANOTECHNOLOGY
### LIST OF NEW SUBJECTS

<table>
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<td>Introductory Nanotechnology</td>
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<td>Characterization and Instrumental Techniques</td>
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**10NT201 PRINCIPLES OF ORGANIC CHEMISTRY**

**Credits:** 3:0:0

**Objectives:**
- The student will get rudimentary ideas on chemical structure and formula of organic molecules
The student will understand the influence of stereoisomerism and conformation in chemical structure and properties of molecules

The student will be exposed to ideas about natural products, their structure, and function

Outcome:
The students will get knowledge on the structural basics of organic compounds

Unit I: Introduction to organic chemistry
Classification of organic compounds – Functional groups – Nomenclature of organic compounds – nomenclature of heterocyclic compounds – fission of bonds – electrophiles and nucleophiles (definition, discussion on the conditions these are formed) – carbocation and carbanion, Free radicals, arynes (structure and reaction only; methods to identify these species are not required)

Unit II: Electronic effects; types of reactions
Inductive effect and field effect – electron delocalization and resonance, rules of resonance – steric inhibition of resonance and steric enhancement of resonance (with only one example for each) – hyperconjugation - tautomerism
Types of reactions: substitution reactions (types and examples), addition reactions (types and examples), elimination reactions (types and examples), rearrangement reactions (types and examples) – thermodynamic and kinetic requirements of a reaction – kinetic and thermodynamic control – the Hammond postulate

Unit III: Stereochemistry I
Stereoisomerism – cis-trans isomerism (definition and examples only) – E, Z nomenclature (rules and examples only) – optical isomerism – cause of optical activity – racemization – resolution methods – absolute configuration – R, S nomenclature – Cahn, Ingold, Prelog nomenclature - Atropisomerism (biphenyls only) – Asymmetric synthesis
Difference between conformation and configuration – conformation of ethane, substituted ethanes – conformation of cyclohexanes, mono, and di-substituted cyclohexanes – saw-horse, staggered, skew, gauche forms

Unit IV: Stereochemistry II

Unit V: Natural products
Nomenclature, classifications, general methods of structure determination of alkaloids, terpenoids, steroids, and flavonoids (structure determination of any specific natural product is not required)

Text Books:
1. P.S. Kalsi, Stereo Chemistry Conformation and Mechanism, New Age Publishing Ltd., New Delhi, 2002

References:

10NT202 QUALITATIVE ANALYSIS AND INORGANIC PREPARATIONS LAB

Credit: 0:0: 2

Qualitative Analysis and Inorganic Preparations:
Analysis of mixtures containing one anion and one cation from the following:
Anions: Carbonate, sulfide, sulphate, chloride, bromide, iodide, acetate, nitrate, oxalate, tartrate, borate, phosphate, arsenate and chromate.

Cations: Lead, copper, bismuth, cadmium, tin, antimony, iron, aluminum, zinc, manganese, nickel, cobalt, calcium, strontium, barium, potassium and ammonium.

Preparations: Any three of the following inorganic preparations:
1. Ferrous ammonium sulphate
2. Tetrammine copper (II) sulphate
3. Potassium trisoxalato chromate (III)
4. Potash alum KAl(SO₄)₂.2H₂O
5. Hexammine cobalt (III) chloride.
6. Manganous sulphate
7. Microcosmic salt
8. Sodium thiosulphate

12 experiments will be notified by HOD from time to time

Reference:

10NT203 ORGANIC REACTIONS AND MECHANISMS

Credits: 4:0:0

Objectives:
- Chemical reactions, which are mostly used to synthesize compounds of various types, and their mechanism are discussed.
- Distinguishing the types of reactions and their mechanism will give an idea of the structural requirements of reactions of a particular type.
- The student will be able to write a reaction by explaining which bonds are broken and in what order.

Outcome:
The students will get a thorough knowledge on reactions of organic compounds in different types mechanisms which he will use in synthesis of nanoscale materials. He will understand how classical chemistry is related to nanochemistry in terms of synthesis.

Unit I: Aromatic and aliphatic nucleophilic substitutions
The S_NAr mechanism – S_N1 mechanism – benzyne mechanism – reactivity – effect of substrate structure, leaving group, attacking nucleophile – Bucherer reaction – Ulmann reaction – Chichibabin reaction
S_N1 and S_N2 mechanisms – neighboring group participation – non-classical carbocations – effect of substrate structure, attacking nucleophile, leaving group, and reaction medium on nucleophilic substitution – ambident nucleophiles and regioselectivity

Unit II: Aromatic and aliphatic electrophilic substitutions

Unit III: Addition and elimination reactions
Addition reactions - Electrophilic, nucleophilic, and free-radical addition to double and triple bonds – hydration, hydroxylation, Michael addition, hydroboration, and epoxidation – Addition to carbonyl compounds – Mannich reaction
Elimination reactions – mechanism – E_1, E_2 mechanisms, Hofmann, Saytzeff rules, Bredt’s rule – Chugaev reaction, Hofmann degradation

Unit IV: Common organic reactions
Aldol, Perkin, Stobbe, Dieckman condensations – Reimer-Tiemann, Reformatsky and Grignard reactions – Gattermann reaction, Kolbe-Schmitt reaction - Friedel-Crafts reaction, Wittig reaction, and Robinson annulation – functional group transformations and inter-
conversion of simple functionalities – Clemmensen, Wolff-Kishner, Meerwein-Pondorf-Verley, and Birch reductions

**Unit V: Molecular rearrangements**

**Text Books**

**Reference Books**

**10NT204 BIOCHEMISTRY**

**Credits: 3:0:0**

**Objectives:**
- The student will get ideas on biomolecular structure and their functional role
- The student will understand the influence of biomolecules in bodily processes
- The student will be exposed to ideas about separation and classification of large molecules

**Outcome:**
- The students will get knowledge about the structure, properties, and action of biomolecules

**Unit I: Proteins and nucleic Acids**
Amino acids and proteins: Definition, General Properties - Primary Secondary, Tertiary, Quaternary and 3-D Structures of Proteins - Chemical Synthesis of Poly peptides. Nucleic acids: Definition, composition, structures of purines, pyrimidines, Phosphodiester bonds and Sugars - Classification of Nucleic acids, Differences between DNA and RNA - Solid Phase synthesis of DNA (Sanger’s method)
Separation and Purification of Amino acids and Proteins: Paper, Gel Filtration Chromatography, Gel Electrophoresis, Western blotting

**Unit II: Carbohydrates and lipids**
Carbohydrate – Definition, classification, conformation of furanose and pyranose rings, general Properties – glycoproteins, proteoglycans: Structure and functions - Fatty acids: Structure, and function - Membrane lipids: classification as phospholipids, sulfolipids, spingolipids and glycolipids, their importance - lipoproteins, diffusion of proteins into the plane of membrane proteins

Unit III: Enzymes: mechanism and kinetics
Enzymes – definition, IUB classification, nomenclature - Enzymes as specific catalyst, Lock & key and induced fit theories, Inhibitors for enzyme reactions - Free energy and transition state changes - Michaelis-Menten and Linewiever-Burk plot - Proteases: facilitators of specific reactions, Protease inhibitors as drugs - Hemoglobin–oxygen binding

Unit IV: Metabolism and bioenergetics
Metabolism – definition, coupled and interconnecting reactions - Metabolic pathways with recurring motifs - Cellular energy: Oxidation of carbon fuels - Role of hormones and signal transduction in the metabolic pathways

Unit V:
Trans-membrane and intracellular receptors - calcium as ubiquitous cytosolic messenger - Glycolysis, HMP-shunt pathway, glycogenesis, glycogenolysis, glyconeogenesis, TCA cycle and mitochondrial Electron transport chain - An overview of amino acid metabolism

Text books:
2. Lehninger, Principles of biochemistry, David L. Nelson, Michael M. Cox, Ed. 4, 2002

Reference books:

10NT205 ORGANIC QUALITATIVE ANALYSIS LAB
Credit: 0:0: 2

Organic Qualitative Analysis:
i. Identification of an organic compound through the functional group analysis, determination of melting point and preparation of suitable derivatives

[Detection of elements (N, S and halogens) and functional groups (phenolic, carboxylic, carbonyl, esters, carbohydrates, amines, amides, nitro and aniline) in simple organic compounds]

ii. Separation of two component mixtures
1) Aniline + Naphthalene 2) Benzoic acid + Benzophenone 3) p-Cresol + Chlorobenzene.

12 experiments will be notified by HOD from time to time
Reference:

10NT206 MATERIALS CHEMISTRY

Credits: 4:0:0

Objectives:
- Since atoms are the building blocks of materials and life, the student will learn the theories behind atomic structure
- The student will learn the types of materials and their bonding features
- The student will be able to distinguish between the chemical and physical nature of various categories of materials

Outcome:
The students will get knowledge on the building blocks of materials, the bonding involved, and their function

Unit I: Atomic structure
Structure of atom – defects of Rutherford’s model - Bohr’s model of an atom – Sommerfield’s extension of atomic structure – electronic configuration and quantum numbers – s, p and d orbitals - Pauli’s exclusion principle – Hund’s rule of maximum multiplicity – Aufbau principle – ionic radius, ionization potential, electron affinity, electronegativity (definitions with examples only; trend in group and period not required) – sigma and pi bonds – hydrogen bonding – Van der Waals’ forces - bond lengths and bond angles (with reference to single and multiple bonds) – Particles: leptons, quarks, gauge bosons, fermions (brief discussion on their charge, physical existence only)

Unit II: Solid state
Crystal structure – crystal symmetry – unit cell – the seven crystal systems – the 14 Bravais lattices – the 32 point groups – space groups – reciprocal lattice - defects in crystals – point defects, line defects, planar defects – dislocations – edge dislocations, screw dislocations – slip and plasticity

Unit III: Metals
Metallurgical bonding – ductility and conductivity – alloys – classification as base metals, ferrous metals, noble metals and precious metal – structure of metals: 12 coordination, 8 coordination, crystal grains – properties of metals – thermal spray, case hardening, plating – metal testing: nondestructive testing – metallography

Unit IV: Polymers
Classification of polymers – polymer morphology: crystallinity, tensile strength, Young’s modulus – phase behavior: glass transition temperature, mixing behavior, inclusion of plasticizers – types of polymerization – mechanisms – important polymers (preparations and uses only): polyethylene, polyvinyl chloride, bakelite, rubber, silicones – polymer degradation

**Unit V: Ceramics and composites**

**Text books:**
1. Brian S. Mitchell, An introduction to materials engineering and science for chemical and material engineers, Wiley Inter-science, 2004

**Reference books:**
3. Wole Soboyejo, Mechanical properties of engineered materials, Marcel Dekker Inc., 2002

**10NT207 INTRODUCTORY NANOTECHNOLOGY**

**Credits: 4:0:0**

**Objectives:**
- As the students have known the basic principles of chemical science he/she will now get introduced to the concept of nanochemistry
- A knowledge on the conceptual origin of nanotechnology and the unique techniques of nanosynthesis as opposed to traditional synthesis will be given
- The student will be exposed to ideas on the conditions to manipulate nanostructures with ease

**Outcome:**
Elementary ideas of origin, and newer chemistry which deals with nanoobjects and the unconventional catalysis using nanoparticles will be given to students

**Unit I: Introduction to nanochemistry**
History of nanotechnology – conceptual origins – experimental advances – role of Richard Feynman, Eric Drexler and Maxwell – prefixing nano before disciplines – nanochemistry - size effects in nanochemistry – brief explanation on top-down and bottom-up approaches – classification as dry and wet nanotechnology
Unit II: Cryochemistry of metal atoms and nanoparticles

Unit III: Catalysis on nanoparticles

Unit IV: Chemical methods in preparation of nanomaterials

Unit V: Other methods in preparation of nanomaterials
Solid-state sintering – grain growth – arc method – ion-beam induced nanostructures – grinding – high energy ball milling – material-ball ratio – control of grain size in the above methods

Text books:

References:
5. H.S. Nalwa, Encyclopedia of nanoscience and nanotechnology, Vol. 1, American scientific publishers, 2004

10NT208 CHARACTERIZATION AND INSTRUMENTAL TECHNIQUES

Credits: 4:0:0

Objectives:
- Since nanotechnology had its origin on the technological advancements of probing structures a study in combination of classical and modern techniques is required
• The student will understand the ways of identifying molecules and materials based on spectral and microscopic techniques
• The student will be able to distinguish between light scattering, absorption, and emission spectral techniques and those do not involve light sources

**Outcome:**
The students will get knowledge on analyzing the structure of molecules and materials

**Unit I: Microscopy; XRD**
Scanning electron microscopy (SEM) – scanning tunneling microscopy (STM) – transmission electron microscopy (TEM) – X-ray diffraction (XRD) – extended X-ray absorption fine structure (EXAFS) (physical principles and instrumentation only to be discussed for all the techniques)

**Unit II: Diffraction and scattering techniques**
Neutron diffraction – low energy electron diffraction (LEED) – reflection high energy electron diffraction (RHEED) – electron energy loss spectroscopy (EELS) - reflected electron energy loss spectroscopy (REELS) - Dynamic light scattering (DLS) (physical principles and instrumentation only to be discussed for all the techniques)

**Unit III: Vibrational spectroscopy**

**Unit IV: Ultraviolet and visible spectroscopy**

**Unit V: Nanotribology; Photoelectron spectroscopy**
Nanotribology – nanotribometer – surface force apparatus – quartz crystal microbalance – friction force microscope – X-ray photoelectron spectroscopy (XPS) – electron spectroscopy for chemical analysis (ESCA) – ultraviolet photoelectron spectroscopy (UPS) (physical principles and instrumentation only to be discussed for all the techniques)

**Text Books:**
References:

10NT209 TITRIMETRIC ANALYSIS AND GRAVIMETRIC ANALYSIS LAB

Credit: 0:0: 2

I. Titrmetric analysis:

a) Acidimetry
   1. Estimation of sodium hydroxide – standard sodium carbonate
   2. Estimation of borax – standard sodium carbonate
   3. Estimation of bicarbonate and carbonate in a mixture

b) Permanganometry
   1. Estimation of oxalic acid - standard - Mohrs salt or ferrous sulphate.
   2. Estimation of calcium
   3. Estimation of sodium nitrite - standard - Oxalic acid
   4. Estimation of ferric ion
   5. Estimation of percentage of manganese in pyrolusite

c) Iodometry
   1. Estimation of arsenious oxide
   2. Estimation of copper – standard potassium dichromate
   3. Estimation of potassium dichromate – standard copper sulphate

e) Complexometry
   1. Estimation of zinc or magnesium using EDTA
   2. Estimation of zinc using potassium ferrocyanide
   3. Estimation of temporary and permanent hardness of water

f) Dichrometry
   1. Estimation of ferrous ion using diphenylamine I N-.Phenyl anthramlic acid as indicator.
   2. Precipitation titration - Estimation of chloride in neutral medium
II. Gravimetric analysis
   1. Determination of barium as barium sulphate
   2. Determination of sulphate as barium sulphate
   3. Determination of lead as lead chromate
   4. Determination of nickel as Ni-DMG complex
   5. Determination of magnesium as magnesium pyrophosphate.

   12 experiments will be notified by HOD from time to time

Reference:

10NT210 INORGANIC AND COORDINATION CHEMISTRY

Credits: 4:0:0

Objectives:
   • The student will get the rudimentary ideas on chemical structure and formula of inorganic and co-ordination compounds
   • The student will understand the differences in bonding of organic molecules (learnt in first semester) with those of inorganic molecules
   • The student will know the basic structure of molecules which are components of supramolecular structures (which he/she will learn in upcoming semesters)

Outcome:
   The students will get knowledge on the structural and reaction basics of inorganic compounds

Unit I: Chemical Bonding; Acid-base concept
Covalent Bond – Valence bond theory and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions - Valence shell electron pair repulsion (VSEPR) theory: postulates and applications - MO theory, bond strength and bond energy, percentage ionic character from dipole moment and electronegativity difference - classification as hard and soft acids and bases - Pearson’s HSAB concept - theoretical basis of hardness and softness - electronegativity and hardness and softness
Unit II: Transition elements and co-ordination compounds
Chemistry of elements of Second and Third transition Series: general characteristics - comparative treatment with their 3d analogues with respect to ionic radii, oxidation states - comparative treatment of elements of second and third transition series- magnetic behavior, spectral properties and stereochemistry - Werner’s coordination theory and its experimental verification, effective atomic number (EAN) concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds

Unit III: Metal-ligand bonding in transition metal complexes and magnetic properties
An elementary idea of crystal field theory - Crystal field splitting in octahedral, tetrahedral and square-planner complexes - factors affecting the crystal field parameters - A brief outline of thermodynamic stability of metal complexes and factors affecting the stability of square planner complexes - types of magnetic behavior, spin (only formula) LS coupling, correlation of $\mu_s$ (spin only) and $\mu_{\text{effective}}$ values - orbital contribution to magnetic moments

Unit IV: Organometallic Compounds
Definition, nomenclature and classification of organometallic compounds – Organo magnesium compounds: the Grignard reagents - formation, structure and chemical reactions – Organo-zinc compounds: formation and chemical reactions – Organo-lithium compounds: formation and chemical reactions – Organo-sulfur Compounds: Nomenclature, structural features, methods of formation and chemical reactions of thiols, sulphonamides and sulphaguanidine - nature of bonding in metal carbonyls

Unit V: Bio-inorganic chemistry

Text books:
1. K. Sarn, Co-Ordination Chemistry, Rajat Publications, New Delhi, 2005

Reference books:
10NT211 PHYSICAL CHEMISTRY

Credits: 4:0:0

Objectives:

- The speed of a reaction and the criteria for reactions to take place will be discussed
- The thermodynamic requirement for a chemical reaction to take place and the criteria for spontaneity and reversibility are to be discussed
- The energy of molecules and quantum chemical explanation given to physical and chemical phenomena will be explained

Outcome:

The students will explain chemical reactions on the basis of energetic considerations

Unit I: Chemical kinetics and catalysis

First order, second order, zero order, and pseudo-first order reactions – Theories of reaction rates: Simple collision theory, absolute reaction rate theory, Arrhenius theory – opposing, parallel and consecutive reactions – kinetic isotopic effect
Acid base catalysis – Bronsted catalysis law – Enzyme catalysis (single substrate reaction only) – Michaelis-Menton law - Surface phenomenon – Gibb’s adsorption isotherm - Physisorption and chemisorption

Unit II: Thermodynamics

First law of thermodynamics, relation between \( C_p \) and \( C_v \), enthalpies of physical and chemical changes – second law of thermodynamics, entropy, Gibbs-Helmholtz equation – third law of thermodynamics and calculation of entropy
Free energy and entropy of mixing, partial molar quantities, Gibbs-Duhem equation – equilibrium constant, temperature dependence of equilibrium constant

Unit III: Electrochemistry


Unit IV: Quantum chemistry I

Black body radiation - Planck’s quantum theory – wave-particle duality – uncertainty principle – operators and commutation relations – postulates of quantum mechanics and Schrodinger equation – particle in one dimensional and three dimensional box - degeneracy - harmonic oscillator - rigid rotator – angular momentum

Unit V: Quantum chemistry II

Variation and perturbation theory – application to helium atom – anti-symmetry and exclusion principle – Slater determinants – term symbols – Born-Oppenheimer approximation – electron density and their role in chemical bonding – hybridization and
valence MOs of $\text{H}_2\text{O}$, and $\text{CH}_4$ – Huckel pi electron theory and its application to ethylene, butadiene, and benzene

Text books:

Reference books:

10NT212 MEDICINAL CHEMISTRY

Credits: 4:0:0

Objectives:
- The student will use his earlier knowledge on organic structures to design a drug
- The student will understand the mechanism of drug action and various phases of drug development
- The student will be exposed to ideas about target-based drug design and clinical trial of drugs

Outcome:
A thorough idea of drug chemistry and the structure–action relationship will be given

Unit I: Basics of medicinal chemistry
Brief history of medicinal chemistry – classification of drugs – brief description of biological, chemical, computer revolutions in drug design – pro drugs and soft drugs – design of pro drug system – multiple pro drug formation – soft drug principle and applications

Unit II: Drug targets and drug solubility
Enzymes and enzyme inhibitors – competitive and non-competitive inhibitors – reversible and irreversible inhibitors – ligand-receptor theories – Clark’s theory and Paton’s rate theory – proteins, lipids, and nucleic acids as drug targets – effect of $\text{pH}$, $\text{pK}_a$, and polarity on drug solubility

Unit III: Pharmacokinetics and drug metabolism
Natural resources of lead compounds – absorption, distribution, metabolism, and elimination – oxidation and hydrolysis – testing drugs in vitro – high-throughput screening – testing drugs in vivo – therapeutic index and therapeutic ratio

Unit IV: Clinical testing and synthesis of drugs

Unit V: Development of new drugs

Text Books:

References:

10NT213 PHYSICAL CHEMISTRY LAB

Credit: 0:0: 2

Physical Chemistry Lab:

1. Chemical kinetics
   i. Determination of specific reaction rate of the hydrolysis of methyl acetate catalyzed by hydrogen ion at room temperature.
   ii. Determination of rate of decomposition of hydrogen peroxide.
   iii. Determination of overall order of saponification of ethyl acetate

2. Distribution law
   i. Determination of distribution coefficient of iodine between water and carbon tetrachloride.
   ii. Determination of molecular status and partition coefficient of benzoic acid in Toluene and water.
3. Electrochemistry
   i. Determination of concentration of HCl conductometrically using standard NaOH solution.
   ii. Determination of concentration of acetic acid conductometrically using standard NaOH solution.
   iii. Determination of dissociation constant (K_a) of acetic acid by conductivity measurements.
   v. Determination of redox potentials of Fe^{2+}/Fe^{3+} by potentiometric titration of ferrous ammonium sulphate vs. potassium dichromate.

4. pH metry
   i. Preparation phosphate buffer solutions
   ii. pH metric titration of weak acid, acetic acid with strong base NaOH and calculation of dissociation constant.

5. Colorimetry
   i. Verification of Beer-Lambert law for KMnO_4, K_2Cr_2O_7 and determination of concentration of the given solution.
   ii. Verification of Beer-Lambert law for CuSO_4 and determination of concentration of the given solution.
   iii. Composition of complex of Cu^{2+} - EDTA disodium salt

6. Adsorption
   i. Surface tension and viscosity of liquids.
   ii. Adsorption of acetic acid on animal charcoal, verification of Freundlich isotherm.

12 experiments will be notified by HOD from time to time

Reference:

10NT214 ANALYTICAL CHEMISTRY AND SPECTROSCOPY

Credits: 4:0:0

Objectives:
- The separation methods of compounds and their purification will be discussed
- The student will understand the structure analysis using spectral techniques
The student will distinguish between the principles of techniques which are used to study solution phase samples and to study solid samples

**Outcome:**

The students will know separation and structure analysis of molecules and materials

**Unit I: Analytical techniques**

Chromatography: theory, instrumentation, basic principles and applications of the following – column, thin layer, and ion-exchange chromatography – HPLC - applications in chemical analysis – gas chromatography
Principles of ORD and CD – Cotton effect – octant rule – axial haloketone rule – applications of ORD and CD in organic and bio-molecules

**Unit II: NMR spectroscopy**


**Unit III: Emission spectroscopy**

Photoluminescence – fluorescence and phosphorescence – Jablonskii diagram – fluorescence polarization – fluorescence correlation spectroscopy (FCS) – fluorescence in-situ hybridization (FISH) – fluorescence confocal microscopy – fluorescence resonance energy transfer (FRET) - (physical principles, instrumentation and applications)

**Unit IV: Mass spectrometry**


**Unit V: Introduction to Crystallography**

Introduction to X-ray crystallography – protein crystallography – problems associated with growing biomolecular crystals – isomorphous replacement in solving crystal structure – interpretation of derived electron density maps – landmark modules in crystallography (physical principles and instrumentation only to be discussed for all the techniques)

**Text books:**

3. Y.R. Sharma, Elements Of Organic Spectroscopy, S. Chand & Company Ltd., New Delhi, 2004
Reference books:
5. Charles Kittel, Introduction to solid state physics, John Wiley and Sons, 1953

10NT215 NANOTECHNOLOGY, GREEN CHEMISTRY AND ENVIRONMENTAL HEALTH

Credits: 4:0:0

Objectives:
- The student will understand the risk and safety of nanotechnology
- The concept of green chemistry will be introduced to the students
- The role of nanotechnology in environmental health will be understood by the student

Outcome:
The environmental applications of nanotechnology and the concept of green chemistry will be learnt by the student

Unit I: Health, policy and energy issues

Unit II: Risks and safe nanotechnology
Nano-objects – exposure routes to nano-objects – effects seen in animal studies – observations from epidemiological studies – hypothesis from animal and epidemiological studies – fire and explosion risk – risk of catalytic reactions – workplace exposures – sampling strategy

Unit III: Working with engineered nanomaterials
Potential for occupational exposure – factors affecting exposure to nanomaterials – elements of risk management programs – engineering controls, dust collection efficiency of filters, work practices, personal protective clothing, respirators, clean-up and disposal of nanomaterials

Unit IV: Introduction to green chemical principles
Definition, tools, and twelve principles of green chemistry, solvent-less reactions and reactions in water, microwaves and fluorous solvents, green resolution of racemic mixtures, materials for a sustainable economy, chemistry of longer wear, agrochemicals: problems and green alternate solutions, Atom efficient processes, evaluating chemical reagents according to their yield and atom efficiency, examples of efficient stoichiometric and catalytic processes, atom economy and homogeneous catalysis, halide-free synthesis and alternatives to Strecker synthesis

Unit V: Greener reagents and products
Greener solvents – the use of volatile organic compounds and the need for innocuous replacements – use of ionic liquids – the use of supercritical CO₂ – solvent-less, solid-supported reagents, and aqueous systems as alternative solvents – greener reagents and products, avoidance of toxic functional groups, minimizing bioavailability and use of auxiliary materials, examples of greener reagents including replacement of phosgene, solid state polymerizations, alternative nitrile synthesis

Text books:

References:
4. Approaches to safe nanotechnology, Department of health and human services, DHHS (NIOSH) publication, 2009
5. www.foresight.org/UTF/Unbound_LBW/

10NT216 MOLECULAR AND MATERIALS SELF-ASSEMBLY

Credits: 4:0:0

Objectives:
• The assembly of nanomaterials of different types will be discussed
• The student will get knowledge on the bottom-up approach in nanotechnology based on self-assembly
• The student will be able to distinguish molecular and materials self-assembly on the basis of the driving force needed for them to form

Outcome:
Self-assembly, which is the most basic of bottom-up building up of nanostructures will be learnt in detail by the student

Unit I: Fundamentals of self-assembly and self-assembled monolayers

Unit II: Layer–by–layer self assembly

Unit III: Nanorod, nanowire self-assembly

Unit IV: Nanocluster self-assembly

Unit V: Self-assembling block copolymers

Text books:

References:

10NT217 CHEMINFORMATICS

Credits: 4:0:0

Objectives:
- The learnt concepts of structure, medicinal properties of chemical species will be applied in describing them using computer
- The graphical way of representation of chemical structures will be discussed
- Choosing the best structure for drug design will be taught

Outcome:
The students gain knowledge on virtual screening methods in structure searching and design

Unit I: Representation of 2D molecular structures

Unit II: Representation of 3D molecular structures

Unit III: Molecular descriptors

Unit IV: Similarity methods

Unit V: Analysis of high-throughput screening data; virtual screening

**Text books:**
1. Andrew R. Leach, Valerie J. Gillet, An introduction to chemoinformatics, Springer, 2005

**Reference books:**

**10NT218 MOLECULAR MACHINES AND MATERIALS**

**Credits: 4:0:0**

**Objectives:**
- Structure, function and classifications of specific nanomaterials will be discussed
- Distinguishing element-based function of nanostructures will be known to the students
- The student will know how these nano-sized materials work strange in suitable conditions

**Outcome:**
The applications of nanostructures in various fields, based on the structure and function of molecular machines, carbon nanostructures, and dendrimers, will be taught to the students

**Unit I: Molecular machines**

**Unit II: Fullerenes, graphenes**
Allotropes of carbon – diamond and graphite; Fullerenes: nomenclature, bucky-balls, carbon nanobuds, solubility, safety and toxicity, fullerites, chemical properties of fullerenes, fullerene reactions – fullerenes as ligands – fullerene synthesis

Unit III: Dendrimers

Unit IV: Nanotubes

Unit V: Quantum dots chemistry

Text books:

Reference books:

10NT219 SYNTHESIS OF ORGANIC COMPOUNDS AND CHROMATOGRAPHY LAB

Credit: 0:0: 2

1. Synthesis of Organic Compounds
   ii. Diazotization and coupling: Preparation of pheryl azo β-naphthol
   iii. Oxidation: Preparation of benzoic acid from benzoyl chloride
iv. Reduction: Preparation of m-nitro aniline from m-dinitro benzene  
v. Esterfication: Preparation of methyl p-nitro benzoate from p-nitro benzoic acid.  
vi. Methylation: Preparation of β-napthyl methyl ether  
vii. Condensation: Preparation of benzilidene aniline and Benzoyl aniline.

2. Thin layer Chromatography & Column Chromatography

i. Preparation of the TLC plates. Checking the purity of the compounds by TLC:  
ii. Acetylation of salicylic acid, aniline, Benzoylation of Aniline and Phenol  
iii. Determination of Rf values and identification of organic compounds by TLC: preparation and separation of 2,4-dinitrophenyl hydrazones of acetone and 2-butanone using toluene and light petroleum(40:60)  
iv. Separation of ortho & para nitro aniline mixture by column chromatography

3. Demonstration experiments:

1. Steam distillation experiment: separation of ortho and para nitro phenols  
2. Microwave assisted Green synthesis, two examples:  
   a. Hydrolysis of Benzamide  
   b. Oxidation of Toluene

12 experiments will be notified by HOD from time to time

Reference:

10NT301 CHEMICAL APPROACH TO NANOMATERIALS

Credits: 4:0:0

Objectives:
- Soft lithographic patterning on the basis of chemistry will be discussed  
- The theory of materials preparation with soft building blocks and large building blocks will be taught to the students  
- The question of how chemistry uses bioinspiration for material preparation will be addressed

Outcome:
The student will get a thorough knowledge of the chemical approach to patterning and synthesis of nanomaterials

Department of Nanotechnology 19.25
Unit I: Nanocontact printing

Unit II: Microspheres

Unit III: Porous materials from soft building blocks

Unit IV: Large building blocks

Unit V: Biomaterials and bioinspiration

Text books:

Reference Books:

10NT302 NANOTOXICOLOGY AND ETHICS

Credits: 4:0:0

Objectives:

- Awareness will be created on the toxicology of nanomaterials among students and the concept of sustainable nanotechnology will be introduced
- The adverse effect of nanoparticles interacting with biological membranes will be discussed
- The ethical agenda to be followed in nanotechnology will be emphasized

Outcome:

The student will understand the toxicology of nanomaterials and his/her responsibility when using nanotechnology

Unit I: Nanotoxicology and sustainable nanotechnology

Size-specific behavior of nanomaterials – nanotoxicology challenges – carbon nanotubes in practice – postproduction processing of carbon nanotubes – physicochemical properties of nanomaterials as mediators of toxicity – characterization of administered nanomaterials during toxicity studies – nanomaterial characterization after administration experiment

Unit II: Nanoparticle exposure


Unit III: Nanoparticle interaction with biological membranes


Unit IV: Approaching the Nano-age

scientists as moral agents – the business community and corporations as moral agents – policy makers and regulators as moral agents – ethical and societal implications – the public interface of science and human values – origins of the precautionary principle – the citizen as moral agent – the language of ethics – meta-ethics and normative ethics

Unit V: The ethical agenda for nanotechnology
The visions of nanotechnology – scenarios in the nanotech marketplace – clarifying purpose – the principle of respect for communities – the principle of the common good – the principle of social justice – utilitarian priorities
The pressing questions – the players – the funders – the thinkers – the communicators – the arenas combined – the role of fore-sighting – ethics applied to the practical – citizenship in the nano-age – the value of the skeptical optimist

Text Books:

References:
1. Niosh, Approaches to Safe Nanotechnology, Department of health and human services, US, 2008

10NT303 NANOTECHNOLOGY IN FUEL CELLS AND ENERGY STORAGE

Credits: 4:0:0

Objectives:
- The application of nanotechnology in energy storage will be discussed
- The question of possibility of alternative energy will be met with on theoretical basis
- The materials in use for such energy storage will be introduced to the students

Outcome:
The student gets an exposure to the role of nanotechnology in meeting the energy needs of the future

Unit I: Nanostructured catalysts for low temperature fuel cells

Unit II: Nanocrystalline solar cells
Dye-sensitized solar cells – cell operation, materials – semiconductor-sensitized solar cells (SSSC) – liquid junction SSSCs – recombination rates in semiconductors – back-transport of electrons from oxide to absorbing semiconductor – electron injection from oxide / substrate into electrolyte
Unit III: Oxides and solid-state SSSCs
Losses in semiconductor aggregates on oxides – multilayer semiconductors – other porous oxides – solid state semiconductor-sensitized solar cells (sSSSCs) – the ETA cell – two-component ETA cells - three-component ETA cells – built-in fields in SSSCs

Unit IV: Nano-scale materials for hydrogen and energy storage

Unit V: Nano-porous organic materials for hydrogen storage

Text Book:

References:
2. Jamelyn D. Holladay, Yong Wang, Evan Jones, Chemical Reviews 2004, 104, 4767 – 4790,

10NT304 SUPRAMOLECULAR CHEMISTRY

Credits: 4:0:0

Objectives:
• As the students have known the structural and functional basics of building blocks of supramolecular structures, he/she will now be taught how to build up such structures
• A knowledge on the driving forces of supramolecular structure formation will be given to the student
• The student will be exposed to ideas on the types of supramolecules based on structure and the chemistry behind host-guest assembly

Outcome:
The structure of supramolecules of various types in solution and solid state and their importance as materials and functional units will be learnt by the student

Unit I: Introduction to supramolecular chemistry

**Unit II: Solution host–guest chemistry**

**Unit III: Supramolecular structures**
Ladders, polygons, and helices – self-assembly using metal templates – racks, ladders, and grids – helicates – molecular polygons
Rotaxanes, catenanes, and knots – topological connectivity – rotaxanes and catenanes as molecular devices – borromeanes – knots (structure and function of the above species)

**Unit IV: Solid state supramolecular chemistry**

**Unit V: Self-assembling capsules**

**Text books:**
1. Jean-Marie Lehn, Supramolecular Chemistry, RCS pubs., 2005

**Reference books:**
1. http://www.uaf.edu/chem/rfk/nano.htm
10NT305 BIOINFORMATICS AND DRUG DESIGNING

Credits: 4:0:0

Objectives:
- The student will be able to distinguish between cheminformatics and bioinformatics
- A knowledge on the protein structure prediction and drug design will be given
- Receptor-based drug optimization will be discussed

Outcome:
The student will be in a ready-to-go state to design drugs in-vitro

Unit I: Introduction to bioinformatics
Introduction to bioinformatics – definition – need – differences between cheminformatics and bioinformatics – benefits of mathematical models – applications – target validation – proteomics, metabolomics, and lipomics: definitions, brief discussion with example – high throughput screening (HTS) and experimental medicine – brief explanation on microarray analysis – need for microarray analysis

Unit II: Force Fields
Force fields - bond stretching - angle bending - introduction to non-bonded interactions - electrostatic interactions - van der Waals interactions - hydrogen bonding in molecular mechanics - force field models for the simulation of liquid water

Unit III: Protein structure prediction and drug design
Protein Structure Prediction - introduction to comparative modeling - sequence Alignment - constructing and evaluating a comparative model - predicting protein structures by 'threading’, molecular docking, AUTODOCK and HEX - structure based de novo ligand design

Unit IV: Computer-assisted drug design

Unit V: Receptor binding sites
Introduction – experimental characterization of binding sites – sequence based approaches to prediction of binding sites – structural approaches – experimental and theoretical determination of binding sites – analyzing and visualization of binding sites – virtual screening approach to receptor-ligand interactions

Text books:
1. Andrew R. Leach, Valerie J. Gillet, An introduction to chemoinformatics, Springer, 2005

Reference books:
1. A.R. Leach, Molecular Modelling Principles and Application, Longman, 1996

10NT306 SYNTHESIS OF NANOMATERIALS AND CHARACTERIZATION LAB

Credit: 0:0: 4

1. Synthesis of nanomaterials
   • Synthesis of Al₂O₃ nanoparticles
   • Synthesis of strontium doped cerium oxide nanoparticles
   • Synthesis of Magnetite nanoparticles (ferro fluid) by co-precipitation method
   • Fabrication of nano silver coating on glass substrate
   • Synthesis of NiO nanoparticles
   • Synthesis of silver nanoparticles by chemical precipitation method
   • Synthesis of gamma – ferric oxide (Meghemite) nanoparticles by simple low temperature route
   • Synthesis of gold nanoparticles
   • Synthesis of copper nanoparticles
   • Preparation of CuO nanorods by wet chemical method

2. Characterization of nanoparticles
   • XRD – crystalline structure, unit cell parameters, ystallite size & theoretical density measurements
   • UV - comparison with standard data
   • FTIR - comparison with standard data
   • SEM - Microstructure determination
   • TEM – Microstructure determination

   12 experiments will be notified by HOD from time to time

10NT307 NANOCOMPOSITES AND QUANTUM COMPUTATION

Credits: 4:0:0
Objectives:
- The student will learn newer concepts and current technology related to nanoscience
- The student will get an enthusiasm on getting involved in science of current importance
- The influence of nanocomposites in newer materials becomes obvious to the students

Outcome:
The student will get updated in knowledge of the current status of nanotechnology and gain knowledge on nanocomposites

Unit I: Quantum computing

Unit II: Pattern formation in chemical and biological systems

Unit III: Introduction to nanocomposites

Unit IV: Processing of nanocomposites

Unit V: Applications of nanocomposites

References:
7. Klaus Friedrich, Stoyko Fakivov, Zhong Shang, Polymer composites from nano to micro scale, Springer, USA, 2005

10NT308 APPLICATIONS OF NANOTECHNOLOGY

Credits: 4:0:0

Objectives:
• The student will learn the advanced applications of nanotechnology

Outcome:
• The student will get updated in knowledge of the current status of nanotechnology and its applications

Unit I: Nano based Inorganic sensors
Density of states (DOS) – DOS of 3D, 2D, 1D and 0D materials – one dimensional gas sensors:- gas sensing with nanostructured thin films – absorption on surfaces – metal oxide modifications by additives – surface modifications – Nano optical sensors – nano mechanical sensors – plasmon resonance sensors with nano particles – AMR, Giant and colossal magnetoresistors – magnetic tunnelling junctions

Unit II: Organic / Biosensors

Unit III: Optical Data Storage
Write and read techniques (signal modulation, disk format, data reproduction), read and write principles (read-only, write-once, phase-change, magnetooptic disks), optical pickup heads (key components, diffraction-limited laser spot, focusing and tracking error signals, servo-loop design, actuator), optical media, near field optical recording, holographic data storage.

Unit IV: Energy Devices
Solar cells - Thin film Si solar cells - Chemical semiconductor solar cells - Dye sensitized solar cells - Polymer solar cells - Nano quantum dot solar cells - Hybrid nano-polymer solar cells.

Unit V: Nano pharmaceuticals

Reference Books

10NT309 NANOELECTROCHEMISTRY AND NANOSCALE THERMODYNAMICS

Credits: 4:0:0

Objectives:
- The student will know electrochemistry as applied to nanoscale science
- Electrode preparation (various types and methods) by principles of nanotechnology will be taught to the students
- The student will understand thermodynamics of nanoscale and the uncertainty in solid-liquid transition temperature in the nanoregime

Outcome:
The applications of nanostructures in various fields, based on the structure and function of molecular machines, carbon nanostructures, and dendrimers, will be taught to the students.

Unit I: Electrochemical techniques in nanostructured materials
Anodic synthesis – Electropolishing and Anodization – Porous anodic alumina – Porous anodic alumina as template – Porous anodic alumina to create nanodevices: Photonic crystals, electrochemical double layer capacitors, light emitting diodes – Medical applications
Cathodic synthesis – Nanowires, template procedures to prepare nanowires – magnetic nanowires – multilayers and superlattices

Unit II: Nanopatterned electrodes
Considerations for choosing a nano electrode fabrication strategy – Nanoelectrode fabrication using top down approaches – cyclic voltammograms recorded at nanopore electrodes: a brief discussion – nanogap electrodes – non high resolution techniques – applications of nanopatterned electrodes

**Unit III: Template synthesis using electrochemistry**
Reactions, diffusion and nucleation in the electrochemical deposition of cobalt nanowires – Theoretical considerations of spherical diffusion at a nano rod array – electrodeposition of magnetic multi layered nano wire arrays – template synthesis of Au/Co multilayered nanowire arrays – Physical properties of electrodeposited nanowires

**Unit IV: Nanoelectrodes**
Nanowires as nanoelectrodes – electrochemical aspects of nanoelectrodes – nanoelectrodes based on chemically modified surface – electrochemical step edge approach – the pre determinant mechanism – atomic metal wires from electrochemical etching – sensing molecular adsorption with quantized nano junction

**Unit V: Thermodynamics and solid-liquid transitions in nanosystems**

References:

**10NT310 NANOTECHNOLOGY AND ENVIRONMENTAL ISSUES**

Credits: 4:0:0

Objectives:
- Analysis of samples in the environment for nanoparticles will be taught to the students
- The treatment of nanoparticles in waste water will be discussed
- The assessment of risks will be taught to the students

Outcome:
The student gets an idea of how to manage risks in the environment due to nanotechnology

**Unit I: Over-viewing manufacturing processes**
Introduction – a brief primer on manufacturing processes – ramifications of worker exposure and environmental issues for nanomanufacturing – four generations of nano-product development – the impact of “engineered” nanomaterials – integrating nanoparticles into nanoproducts

**Unit II: Analyses of nanoparticles in the environment**

Unit III: Treatment of nanoparticles in waste water

Unit IV: Environmental fate and transport

Unit V: Risk assessment

Text Book:

References:
1. Barbara Karn, Nanotechnology and the environment applications and implications, American Chemical Society, Oxford University Press (Washington, DC), 2005

10NT311 BIOLOGICAL NANOSTRUCTURES

Credits: 4:0:0

Objectives:
- Usage of biomaterials as nanostructures will be taught to the students
- The application of biological molecules in newer materials will be discussed
- The assessment of risks will be taught to the students

Outcome:
- The student gets an idea of how to make nanostructures from biological molecules and apply them in various fields
Unit I: Protein S-layers and nanopores

Unit II: Programmed assembly and nanocontainers
Introduction, ordering from chaos - Monitoring enrichment - Quantification of binding and criteria for specificity - Microbial nanoparticle production - Polymer nanocontainers: Introduction and in therapy - Liposomes in biotechnology - Shell cross-linked Knedels (SCKs) - Block co-polymer hybrids - Stimuli responsive nanocapsules

Unit III: Biomolecular motors and assemblies

Unit IV: DNA-templated electronics
Introduction to DNA-templated Electronics - Sequence-specific molecular lithography - DNA interaction into microelectronic arrays - DNA branching for network formation - Controlled cluster growth on DNA templates - Conductivity measurements on metallized DNA wires - DNA junctions - DNA metallization - DNA site specific attachment

Unit V: Biomimetic ferritins; DNA-nanoparticle conjugates
Introduction to Biomimetic Ferritins - High-density magnetic data storage by ferritins - DNA-gold nanoparticles conjugation - Nanoparticles based DNA and RNA detection assays - DNA nanoparticles detection of proteins - Methods and protocols: DNA nanoparticles conjugation - Applications and challenges ahead - Nanoparticles for drug and gene targeting - Non-viral nanomaterials in development and testing - Setbacks and strategies to improve specific cell uptake of non-viral systems

Text books:
1. Michael Stroscio, Mitra Dutta, Biological nanostructures and applications of nanostructures in biology, Kluwer academic publishers, 2004

Reference books:
2. JB Park, Biomaterials science and engineering, Ed. 2, Narosa publishers, New Delhi, 2005
10NT312 NANOBIOTECHNOLOGY

Credits: 4:0:0

Course Objectives:
- To know about biology inspired concepts, nanobiometrics, natural nanocomposites, nano analytics and molecular manufacturing

Outcome
- Students acquire a good understanding on the basic principles and applications of nanobiotechnology

Unit I

Unit II
Nano biometrics-introduction-lipids as nanobricks and mortar, self assembled nanolayers-the bits that do think-proteins-three dimensional structures using a 20 aminoacid-biological computing-a protein based 3D optical memory using DNA to build nano cubes and hinges-DNA as smart glue-DNA as wire template-DNA computers.

Unit III
Natural nanocomposites-introduction-natural nano composite materials-biologically synthesized nanostructures-biologically derived synthetic nanocomposites-protein based nanostructure formation-biologically inspired nanocomposites-nanotechnology in Agriculture [Fertilizers and Pesticides].

Unit IV
Nano analytics-quantum dot biolabeling-nanoparticle molecular labels-analysis of biomolecular structure by AFM and molecular pulling-force spectroscopy-biofunctionalized nanoparticles for surface enhanced raman scattering and surface Plasmon resonance.

Unit V
Molecular Manufacturing-Nano simulation, implications of nanotechnology, health and safety implications from nanoparticles. Health issues-Environmental issues-need for regulation-social implications, possible military applications-potential benefits and risks for developing countries-studies on the implications of nanotechnology.

Reference Books:
5. Tuan Vo-Dinh, Protein Nanotechnology Protocols, Instrumentation and Application, Series ; Methods in Molecular Biology (2005)

10NT313 ADVANCED EXPERIMENTS & SIMULATIONS TECHNIQUES FOR NANOPARTICLE CHARACTERIZATION LAB

Credits: 0:0:3

Course Objectives:
- To characterize the nanoparticles by advanced characterization techniques such as UV Visible spectroscopy, XRD techniques, SEM, TEM, Electrochemical techniques, etc.

Outcome
- From this course, students can able to understand methods of characterizing nanomaterials

12 experiments will be notified by the HOD from time to time

10NT314 EXPERIMENTAL TECHNIQUES FOR NANOBIOTECHNOLOGY LAB

Credits: 0:0:3

Course Objectives:
- To synthesize nanoparticles by nanobiotechnological routes

Outcome
- Students acquire a good understanding on the methods of synthesizing nanomaterials by biotechnological based processes.

12 experiments will be notified by the HOD from time to time
NANOTECHNOLOGY
ADDITIONAL SUBJECT

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<th>Code</th>
<th>Subject Name</th>
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<td>10NT220</td>
<td>Fundamentals of Nanotechnology</td>
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10NT220 – FUNDAMENTALS OF NANOTECHNOLOGY

Credits: 4:0:0

Course Objective: To study the basics and important applications of nanotechnology.

Course Outcome: The candidates will be familiar with the basics of nanotechnology, tools used for characterizing nanomaterials and specific applications of nanotechnology.

Unit I Basics of nanotechnology
Definition of nanotechnology - Living with nanoparticles - Nanotechnology, a Future trillion dollar business - Nanotechnology will develop in stages; Nanotechnology products and applications - Future applications of nanotechnology – Medical applications.

Unit II The science of nanotechnology

Unit III The nanotechnology tool box

Unit IV Nanotechnology in medicine and health
Cardiovascular diseases - Cancer detection and diagnosis - Diabetes and nanotechnology - Implants and prosthetics - Nanotechnology and burn victims - Diagnosis and therapy - Drug delivery using nanoparticles - Nanotechnology fights infections - Pharmaceutical nanotechnology research.

Unit V The business of nanotechnology
Nanotechnologies in businesses - Sporting goods equipment - Chewing gum and nanocrystals - Apparel industry – Cosmetic – Appliances - Electronics and computers - Automobile/vehicle industry - Aircraft potential and metal rubber - Paint and other water resistance coatings - Removing windshield fog - Self-cleaning glass - Antibacterial cleansers - Medical bandages - Solar energy: Photovoltaic cells - working principle - Battery technology (Brief description only) – Fuel cells (Brief description only)
Text Books:

ADDITIONAL SUBJECT

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10NT220 – FUNDAMENTALS OF NANOTECHNOLOGY

Credit: 4:0:0

Course Objective: To study the basics and important applications of nanotechnology.

Course Outcome: The candidates will be familiar with the basics of nanotechnology, tools used for characterizing nanomaterials and specific applications of nanotechnology.

Unit-I: Basics of nanotechnology
Definition of nanotechnology - Living with nanoparticles - Nanotechnology, a Future trillion dollar business - Nanotechnology will develop in stages; Nanotechnology products and applications - Future applications of nanotechnology – Medical applications.

Unit-II: The science of nanotechnology

Unit-III: The nanotechnology tool box

Unit-IV: Nanotechnology in medicine and health
Cardiovascular diseases - Cancer detection and diagnosis - Diabetes and nanotechnology - Implants and prosthetics - Nanotechnology and burn victims - Diagnosis and therapy - Drug delivery using nanoparticles - Nanotechnology fights infections - Pharmaceutical nanotechnology research.

Unit-V: The business of nanotechnology
Nanotechnologies in businesses - Sporting goods equipment - Chewing gum and nanocrystals - Apparel industry – Cosmetic – Appliances - Electronics and computers - Automobile/vehicle industry - Aircraft potential and metal rubber - Paint and other water resistance coatings - Removing windshield fog - Self-cleaning glass - Antibacterial cleansers - Medical bandages - Solar energy: Photovoltaic cells - working principle - Battery technology (Brief description only) – Fuel cells (Brief description only)
Text Books:
ADDITIONAL SUBJECTS

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<td>Intermolecular And Surface Forces In Nanotechnology Applications.</td>
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<td>2.</td>
<td>11NT302</td>
<td>Nanolithography</td>
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<td>3.</td>
<td>11NT303</td>
<td>Synthetic Methodologies for Nanomaterials</td>
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<td>4.</td>
<td>11NT304</td>
<td>Engineering Principles for Nano Technology</td>
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<td>5.</td>
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<td>11NT306</td>
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<td>Nanocomposites</td>
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<td>10.</td>
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<td>Nanotechnology for Advanced Drug Delivery Systems</td>
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<td>Experimental Techniques for Nanobiotechnology</td>
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<td>12.</td>
<td>11NT312</td>
<td>Nanosensors and Transducers</td>
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<td>13.</td>
<td>11NT313</td>
<td>Industrial Nanotechnology</td>
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11NT301  INTERMOLECULAR AND SURFACE FORCES IN NANOTECHNOLOGY APPLICATIONS.

Credits 4:0:0

Course Objective:
To learn the basic concepts of intermolecular forces, surface forces and contact forces and study advanced concepts of these forces in nanotechnology applications.

Course Outcome:
Students should be able to understand the concepts of intermolecular forces, surface forces and contact forces and analyze effects these forces in nanotechnology applications.

UNIT I: Overview of Molecular Forces
UNIT II: Forces between Atoms and Molecules

UNIT III: Forces between Particles and Surfaces
van der Waal’s force between surfaces- Hamaker constant-molecule- surface, surface-surface for different geometries: sphere-sphere, sphere-plane, plane-plane, cylinder-cylinder- - Electrostatic forces between surfaces –electric double layer-Poisson-Boltzman (PB) equation- surface charge- electric field –counter ion concentration- PB Limitations-Debey length- DLVO forces. Non-DLVO forces-solvation-structural-hydration forces-hydrophobic-hydrophilic interactions-steric and fluctuation forces

UNIT IV: Force Measuring Techniques

UNIT V: Applications in Nanotechnology
Nanoparticles, problem of agglomeration and clusters in nanoparticles and Geeko Feet adhesion, NEMS- MEMS adhesion.

Text Books

Reference Books

11NT302 NANOLITHOGRAPHY

Credits: 4:0:0

Course Objective:
To learn the basic concepts, methods, tools, applications and issues of lithography and study the advanced concepts and tools required for realizing and manipulating devices and nano-scale dimensions.

Course Outcome:
Students should be able to understand the concepts involved in lithography and design lithographic masks for a given micro- and nano- devices and circuits.
Unit I – Introduction to Lithography
Introduction to lithography – Lithography process steps; Mask making, wafer pre-heat, resist spinning, pre-bake, exposure, development & rinsing, post-bake, oxide etching and resist stripping - Alignment marks in mask plate – Optical lithography – Light sources – Contact, proximity and projection printing and their modulation transfer function - Resolution in projection systems – Resists - Positive and negative photo resists and their comparison in terms of various parameters – Lift-off profile

Unit II – Applications of Lithography
Application of lithography – Semiconductor IC fabrication – Fabrication of n-type/p-type MOSFETs using metal gate and self-aligned poly-gate with lithographic masks – Fabrication of CMOS FET using p-well and n-well process with lithographic masks – Fabrication of NPN and PNP BJT with lithographic masks – MEMS design flow - MEMS based pressure and acceleration sensor fabrication using lithographic masks – Advantages of scale-down approach in semiconductor ICs and MEMS sensors – Limitations of optical lithography.

Unit III – Next Generation Lithographic Techniques

Unit IV – Nanolithography

Unit V – Tools for Nanolithography

Text Books

Reference Books
11NT303 SYNTHETIC METHODOLOGIES FOR NANOMATERIALS

Credits  4:0:0

Course Objective:
To learn and understand basic and advanced concepts of synthetic techniques and methodologies used for nanomaterials preparations.

Course Outcome:
The students should be able understand basic and advanced synthetic methodologies and techniques used for nanomaterials preparations.

Unit I - Chemical methods

Unit II - Carbon and related materials

Unit III - Mechanical methods
Grinding – high energy ball milling – types of balls – WC and ZrO2 – material-ball ratio – medium for grinding – limitations in getting required grain size for low melting point materials – typical systems – severe plastic deformation – melt quenching and annealing

Unit IV - Ultra high vacuum system

Unit V - Nanopolymers
Nanopolymers – Preparation and characterization of diblock Copolymer based nanocomposites, Nanoparticles polymer ensembles; Assembly of polymer – Nanoparticles composite material; Fabrication of polymer-mediated organized Nanoparticles assemblies; Applications of Nanopolymers in Catalysis.

Text Books
1. Vacuum Technology & Coating, 2000, Cowan & Co

Reference Books
11NT304 ENGINEERING PRINCIPLES FOR NANOTECHNOLOGY

Credits 4:0:0

Course Objective:
To learn and understand basic and advanced concepts of engineering principles for nanotechnology:

Course Outcome:
The students should be able to understand basic and advanced concepts engineering principles in nanotechnology applications.

Unit I - Thin Film Technology
Electro plating, Electroless plating, Langmuir- Blodget films, Thermal growth, Chemical vapour deposition, sputtering deposition, molecular beam epitaxy atomistic nucleation process, cluster coalescence and deposition, grain structure of films and coatings, amorphous thin films.

Unit II - Analysis of Thin films
Mechanical, electrical, magnetic and optical properties of thin films- Analysis of thin films.

Unit III - Vacuumed Technology
Pump selection and exhaust handling, rotary oil pumps, roots pump, diffusion pumps, turbo molecular pump, cryo pump, sputter-ion pump, pressure measurements, thermodynamics of evaporation, evaporation rate, alloys, compounds, sources, transport and deposition monitoring.

Unit IV - MEMS

Unit V - Silicon Technology
Semiconductor as base material- band diagram of semiconductor- band diagram of inhomogeneous semiconductor- different types of components in semiconductor, different types of transistor integration- technological processes for microminiaturizationmethods and limits of microminiaturization in silicon.

Text Books

Reference Books

**11NT305 SYNTHESIS OF NANOMATERIALS**

**Credits 0:0:4**

**Course Objective:**
To synthesize nanomaterials by various chemical and physical routes

**Course Outcome:**
The student will understand the methodology of synthesizing nanomaterials by different processes and techniques.

12 experiments will be notified by the HOD from time to time

**Experiments List:**

1. Synthesis of Alumina (Al₂O₃) nanoparticles
2. Synthesis of Mg₆Al₃O₁₂ nanoparticles (Spinel)
3. Synthesis of Strontium doped cerium oxide (CeO₂) nanoparticles
4. Synthesis of nano BaCeO₃ powder
5. Synthesis of γ-LiAlO₂ nanoparticles
6. Synthesis of Magnetite Nanoparticles (Aqueous Ferrofluid)
7. Synthesis of Nickel Oxide nanoparticles by chemical precipitation method
8. Fabrication of nano silver coating on glass substrate
9. Synthesis of silver nanoparticles by chemical reduction method
10. Synthesis of γ-Fe₂O₃ (Maghemite) nanoparticles by simple low temperature route
11. Chemical Synthesis of MgO nanoparticles
12. Preparation of CuO nanorods by wet chemical method
13. Synthesis of Fe₂O₃ nanoparticles by new sol-gel method
14. Synthesis of cadmium sulphide nanocrystals
15. Preparation of Barium Sulphate nanocrystals by aqueous colloidal method
16. Preparation of CuO nanorods using Ultrasonic bath
17. Synthesis of gold nanoparticles
18. Preparation and characterization of PCL (Poly Capro Lactum) nanospheres for drug delivery application

**11NT306 THERMODYNAMICS AND QUANTUM MECHANICS FOR NANO SCALE SYSTEMS**

**Credits 4:0:0**

**Course Objective:**
To learn and understand basic and advanced concepts of thermodynamics, statistical mechanics and quantum mechanics in the perspective nanoscale systems.
Course Outcome:
The students should be able to understand the basic and advanced concepts to analyze the nanoscale systems

Unit I - Review of the Laws of Thermodynamics and their Consequences

Unit II - Statistical Description of Systems of Particles

Unit III - Quantum mechanics
Quantum Mechanics -Review of classical mechanics -de Broglie's hypothesis -Heisenberg uncertainty principle -Pauli exclusion principle -Schrödinger's equation -Properties of the wave function -Application: quantum well, wire, dot -Quantum cryptography

Unit IV - Electrical and magnetic properties
Electronic and electrical properties-One dimensional systems-Metallic nanowires and quantum conductance - dependence on chirality -Quantum dots -Two dimensional systems -Quantum wells and modulation doping -Resonant tunnelling -Magnetic properties Transport in a magnetic field -Quantum Hall effect. -Spin valves -Spin-tunnelling junctions -Domain pinning at constricted geometries -Magnetic vortices

Unit V - Mechanical and Optical Properties
Mechanical properties -Individual nanostructures - Bulk nanostructured materials-Ways of measuring-Optical properties-Two dimensional systems (quantum wells)-Absorption spectra -Excitons -Coupled wells and superlattices - Quantum confined Stark effect

Text Books

Reference Books
1. Statistical Mechanics – Bipin K. Agarwal and Melvin Einsner
11NT307 NANO Elec tronics

Credits 4:0:0

Course Objective:
To learn and understand basic and advance concepts of nanoelectronics.

Course Outcome:
The students should be able to understand basic and advanced concepts of nanoelectronic devices, sensors and transducers and their applications in nanotechnology.

Unit I
Basics of nanoelectronics – capabilities of nanoelectronics – physical fundamentals of nanoelectronics – basics of information theory – the tools for micro and nano fabrication – basics of lithographic techniques for Nanoelectronics

Unit II

Unit III

Unit IV

Unit V

Text Books
1. Nanoelectronics and Nanosystems, Karl Goser, Peter Glosekotter, Jan Dienstuhl,

11NT308 ADVANCED EXPERIMENTS AND SIMULATION TECHNIQUES FOR NANOPARTICLE CHARACTERIZATION

Credits 0:0: 4

Course Objective:
To learn and have hand-on experience with advanced nanotechnology characterization techniques

Course Outcome:
The students should be able to handle the characterization tools independently and analyze the data using technical software.
12 experiments will be notified by the HOD from time to time

Experiment details
1. Green synthesis of nanoparticles and its characterization using UV-Vis Spectroscopy
2. Characterization of Fe₂O₃ and Al₂O₃ nanoparticles using X-ray Diffraction
3. Morphological study of nanomaterials using Scanning Electron Microscopy
4. Photoluminesence studies of nanomaterials
5. Analysis of nanoparticles and nano thin films by Atomic Force Microscopy
6. Synthesis and characterization of Zero Valent Ion nanoparticles
7. Synthesis of nanoparticles and its characterization using Particle Size Analyzer (DLS)
8. Preparation characterization of polymer nanocomposite membrane
9. Characterizations of Ball Milled nanoparticles
10. I-V studies of nanomaterials.
11. Molecular Simulation
12. Molecular Dynamic Simulation

CASE STUDY
Cyclic Voltametry study of nanomaterials
Chemical Vapor Deposition techniques
Physical Vapor Deposition techniques
Electro-spinning techniques
11NT309 NANOCOMPOSITES

Credits 4:0:0

Course Objective:
To learn and understand structure - property correlation of various nanocomposites.

Course Outcome:
The students should be able to understand the structure-property relations of various nanocomposites used for engineering and biomedical applications.

UNIT I - Introduction of nanocomposites

UNIT II - Properties and features of nanocomposites

UNIT III - Processing of nanocomposites
Viscosity - Types of flow – Viscosity - Experimental viscosity - Non-newtonian Flow - Low-viscosity processing - Solvent processing - Particle behavior – In-situ polymerization - Post-Forming - Hazards of solvent Processing - Melt, high-shear, and direct processing - Melting and softening - Melt processes with small shears or low-shear rates flow - Melt processes with large deformations or high-shear rates - Thermo-kinetic processes

UNIT IV - Characterization of nanocomposites

UNIT V: Applications of nanocomposites
Nanocomposites – Optical, structural applications – Nanoparticulate systems with organic matrices – Applications – Biodegradable protein nanocomposites - Applications Polypropylene nanocomposites – Application as exterior automatic components – Hybrid nanocomposite materials – Application for corrosion protection

Text books

Reference books

2. Biodegradable polymers for Industrial Applications, Ray Smith, CRC Press, 2005
5. Nanocomposites, Parag Diwan and Ashish Bharadwaj, Pentagon Press

11NT310 NANOTECHNOLOGY FOR ADVANCED DRUG DELIVERY SYSTEMS
Credits: 4:0:0

Course Objective:
To learn and understand basic and advanced concepts of nanotechnological drug delivery systems.

Course Outcome:
The students should be able to understand various methods of nanotechnological drug delivery systems.

UNIT I Principles of drug delivery systems:
Modes of drug delivery, ADME hypothesis-controlled drug delivery, site specific drugs, barriers for drug targeting, passive and active targeting, Strategies for site specific, time and rate controlled delivery drugs, antibody-based and metabolism based targeting.

UNIT II Targeted Nanoparticles for drug delivery:
Nanoparticle surface modification, bioconjugation, pegylation, antibodies cell-specific targeting and controlled drug release, Multi-Functional Gold Nanoparticles for Drug Delivery, Virus based nanoparticles.

UNIT III Dentrimer as Nanoparticular Drug Carriers:
Synthesis- Nanoscale containers- Nanoscafoled-Gene transpektion- Biocompatibility-Polymer Micelles as Drug carriers, Polymer Nanotubes-Magnetic Nanoparticles as Drug Carriers.

UNIT IV: Liposomes for drug delivery and targeting:
Classification and preparation of liposomal nanoparticles. Liposomes for pharmaceutical and cosmetic applications, Liposomal Drug Carriers in Cancer Therapy, Lipid-DNA
complexes, Viral gene transpection system, Lipid based drug delivery system for peptide and protein drug delivery, Liposomal anticancer and anti fungal agents.

UNIT V: Nanoparticle and targeted systems for cancer diagnosis and therapy:
Targeted delivery through enhanced permeability and retention. Folate receptors, Targeting through angiogenesis, Targeting to specific organs or tumour types, Tumour specific targeting: Breast cancer, Liver targeting tumour, vasculature for imaging, Delivery of specific anticancer agents: such as Paclitaxel, Doxorubicin, 5-Fluorouracil etc

Text Books

Reference Books

11NT311 EXPERIMENTAL TECHNIQUES FOR NANOBIO TECHNOLOGY

Credits 0:0:4

Course Objective:
To learn and have hand-on experience with the synthesis of nanobiomaterials and relevant characterization techniques.

Course Outcome:
The students should be able to handle the experiments tools independently and synthesize the nanobiomaterials.

12 experiments will be notified by the HOD from time to time

Experiments
1. Isolation of Genomic DNA from Plant Tissue
2. Isolation of Genomic DNA from Animal Tissue
3. Digestion of Plasmid DNA & Testing with Agarose gel Electrophoresis
4. Ligation of fragmented Plasmid DNA
5. Liposomes for Drug Delivery
6. Antimicrobial Activity of Microdiscs
7. Antimicrobial Activity of Zero Valent Iron Nanoparticles
8. Sodium Alginate Nanospheres
9. Microspheres for Drug Delivery
10. Determination of Drug loading in Nanosphere
12. PCR (Polymerase Chain Reaction) Amplification of DNA

11NT312 NANOSENSORS AND TRANSDUCERS
Course Objective:
To learn and understand basic and advanced concepts of nanosensors and transducers for nanotechnology applications:

Course Outcome:
The students should be able to understand nanosensors and transducers used in nanotechnology applications

Unit I: Transducers

Unit II: Sensor Characteristics and Physical effects:

Unit III: Nano based Inorganic sensors

Unit IV: Organic / Biosensors

Unit V: Signal conditioning and data acquisition
sensitive detectors (PSD:- Linear switching PSD – Multiplying PSD – Digital PSD – Edge triggered PSD) – Phase locked loop.

Text Books


Reference Books


11NT313 INDUSTRIAL NANOTECHNOLOGY

Credits 4:0:0

Course Objective:
To learn and understand basic and advanced concepts of industrial nanotechnology.

Course Outcome:
The students should be able to understand industrial nanotechnology devices, sensors and transducers and their applications

Unit I - Overview of Information Storage and Nanotechnology
Different types of information storage materials and devices: solid state memory, optical memory, magnetic recording, emerging technologies, role of nanotechnology in data storage.

Unit II - Optical Data Storage
Write and read techniques (signal modulation, disk format, data reproduction), read and write principles (read-only, write-once, phase-change, magneto-optic disks), optical pickup heads (key components, diffraction-limited laser spot, focusing and tracking error signals, servo-loop design, actuator), optical media, near field optical recording, holographic data storage.

Unit III – Energy Devices

Unit IV – Nano pharmaceuticals
Unit V - Industrial applications of nanomaterials

Text Books

3. Nanoelectronics and Information Technology, Rainer Waser, John Wiely and sons publication, 2003

Reference Books

2. Nanoelectronics, Dr. Parag Diwan and Ashish Bharadwaj, Pentagon press, 2006
<table>
<thead>
<tr>
<th>Sub. Code</th>
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<th>Credits</th>
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<td>12NT201</td>
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<td>Molecular Simulation Lab</td>
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<td>12NT205</td>
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<td>12NT206</td>
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<td>12NT301</td>
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<td>Synthesis of Nanomaterials (Lab)</td>
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<td>Thermodynamics and Quantum Mechanics for Nanoscale Systems</td>
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<td>Advanced Experiments and Simulation Techniques for Nanoparticle Characterization</td>
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<td>12NT316</td>
<td>Nanotechnology for Advanced Drug Delivery Systems</td>
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<td>12NT317</td>
<td>Experimental Techniques for Nano-biotechnology (Lab)</td>
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<td>Intermolecular and Surface Forces in Nanotechnology Applications</td>
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<td>Nanobiomaterials</td>
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<td>Basic Principles of Chemistry</td>
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<td>Elementary Biology</td>
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<td>Basic Electronics</td>
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<td>Quantum Mechanics</td>
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<tr>
<td>12NS211</td>
<td>Materials Science Engineering</td>
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11NT201 APPLICATIONS OF NANOTECHNOLOGY

Credits 3:0:0

Course Objective:
- To learn the basic concepts of nanosciences and nanotechnology and their applications in various fields of science and engineering

Course Outcome:
- Students should be able to understand the basic concepts of nanosciences and nanotechnology and their applications in various fields of science and engineering

Unit I
Overview of Nanotechnology: Basic of Nanotechnology- Applications of nanotechnology- state of art of nanotechnology- relevance of nanotechnology- impact on economy and future development.

Unit II

Unit III

Unit IV
Nanotechnology in Engineering: Applications of nanotechnology in various fields of engineering-Development of sensors- devices-electronic devices- electromechanical devices-optoelectronic devices-computer memory-CPU etc.

Unit V
Nanotechnology in Biology: Applications of nanotechnology in biomedical fields- drug development and delivery-biomedical sensors- devices- development of biomaterials for tissue and bone replacement.

Text Books:
2. Video and Text Resources available in www.nanohub.org
3. Resources available in various national and international organizations.

References:
2. www.nanohub.org
3. www.wikipedia.org
4. www.foresight.org/nano
12NT201 INTRODUCTORY NANOTECHNOLOGY

Credit: 4:0:0

Course Objective:
• To introduce the basic concepts of nanotechnology in which the various nanotechnology related concepts, nano materials, and various synthesis techniques.

Course Outcome:
• The student will be able to understand the nanotechnology concepts
• Students will get the knowledge on recent nano-materials and their advancement
• Student can learn in depth on various nanomaterial synthesis procedures.

Unit I

Unit II
Fullerenes, CNT and Graphene: Allotropies of Carbon, Types of CNT, Introduction on Fullerenes, CNT, Discovery and early years, Synthesis and purification of fullerenes, CNTs, Chemistry of fullerenes in the condensed phase, Endohedral chemistry of fullerenes, Pressure effects, conductivity and superconductivity in doped fullerenes, Ferromagnetism in C60, Optical and other unusual properties. Graphene - introduction, their unusual properties, various synthesis methodologies, present and future applications.

Unit III

Unit IV

Unit V
Text Books

References Books

12NT202  FUNDAMENTALS OF NANOTECHNOLOGY

Credits: 4:0:0

Course Objective:
- To study the basics and important applications of nanotechnology.

Course Outcome:
- The candidates will be familiar with the basics of nanotechnology, tools used for characterizing nanomaterials and specific applications of nanotechnology.

Unit I
Basics of Nanotechnology: Definition of nanotechnology - Living with nanoparticles - Nanotechnology, a Future trillion dollar business - Nanotechnology will develop in stages; Nanotechnology products and applications - Future applications of nanotechnology – Medical applications.

Unit II

Unit III

Unit IV
Nanotechnology in Medicine and Health: Cardiovascular diseases - Cancer detection and diagnosis - Diabetes and nanotechnology - Implants and prosthetics - Nanotechnology and burn
victims - Diagnosis and therapy - Drug delivery using nanoparticles - Nanotechnology fights infections - Pharmaceutical nanotechnology research.

Unit V
The Business of Nanotechnology: Nanotechnologies in businesses - Sporting goods equipment - Chewing gum and nanocrystals - Apparel industry – Cosmetic – Appliances - Electronics and computers - Automobile/vehicle industry - Aircraft potential and metal rubber - Paint and other water resistance coatings - Removing windshield fog - Self-cleaning glass - Antibacterial cleansers - Medical bandages - Solar energy: Photovoltaic cells - working principle - Battery technology (Brief description only) – Fuel cells (Brief description only)

Text Books:

Reference Books:

12NT203 INTRODUCTION TO MOLECULAR SIMULATIONS

Credit: 4:0:0
Course Objectives:
- To introduce the molecular simulation techniques, with special focus on molecular dynamics and Monte Carlo.
- To develop their own codes and utilize the learned methods towards solving a problem of their interest in Nanotechnology Applications.

Course Outcome:
- To solve the Nanoscience and the technology problems using the molecular stimulation

Unit I

Unit II

Unit III
Statistical Mechanics for Molecular Simulations: Ensembles- Micro canonical Ensemble (NVE), Canonical ensemble (NVT), Isothermal-Isobaric Ensemble, Grand canonical ensemble, Observables-Temperature, Pressure, Thermostats, Barostats-Andersen- Berendsen, Nose-Hoover

Unit IV

Unit V
Molecular Dynamics Simulations: Molecular dynamics (MD) – formulation, MD – dynamic information, MD – applications, Euler -Verlet algorithms, Analysis trajectories, Correlations functions, Autocorrelations function (ACF), Structure Correlations Function (SCF). MD-Open Source Simulations tools.

Text Books

Reference Books

12NT204 MOLECULAR SIMULATION LAB
Credit: 0:0:1

Course Objective:
- To understand the molecular simulation for various materials structures

Course Outcome:
- Student will get knowledge in simulation software and expertise in molecular simulations

1. Hands on experience on Molecular Dynamics Virtual Simulation Tools
3. Molecular Dynamics Simulations – Physical Properties Calculation
4. Molecular Dynamics Simulations of higher order systems
5. Hands on experience on Monte Carlo virtual simulation tools
6. Monte Carlo Simulations Energy minimization
7. Monte Carlo Simulation (Ising Model)
8. Monte Carlo Simulation (Hard Sphere)

6 experiments will be notified by the HOD from time to time
12NT205 NANOTECHNOLOGY, GREEN CHEMISTRY AND ENVIRONMENTAL HEALTH

Credits: 4:0:0

Course Objective

• The student will understand the risk and safety of nanotechnology
• The concept of green chemistry will be introduced to the students
• The role of nanotechnology in environmental health will be understood by the student

Course Outcome

• The environmental applications of nanotechnology and the concept of green chemistry will be learnt by the student

Unit I

Unit II
Risks and Safe Nanotechnology: Nano-objects – exposure routes to nano-objects – effects seen in animal studies – observations from epidemiological studies – hypothesis from animal and epidemiological studies – fire and explosion risk – risk of catalytic reactions – workplace exposures – sampling strategy.

Unit III

Unit IV:
Introduction to Green Chemical Principles: Definition, tools, and twelve principles of green chemistry, solvent-less reactions and reactions in water, microwaves and fluorous solvents, green resolution of racemic mixtures, materials for a sustainable economy, chemistry of longer wear, agrochemicals: problems and green alternate solutions, Atom efficient processes, evaluating chemical reagents according to their yield and atom efficiency, examples of efficient stoichiometric and catalytic processes, atom economy and homogeneous catalysis, halide-free synthesis and alternatives to Strecker synthesis

Unit V
Greener Reagents and Products: Greener solvents – the use of volatile organic compounds and the need for innocuous replacements – use of ionic liquids – the use of
supercritical CO₂ – solvent-less, solid-supported reagents, and aqueous systems as alternative solvents – greener reagents and products, avoidance of toxic functional groups, minimizing bioavailability and use of auxiliary materials, examples of greener reagents including replacement of phosgene, solid state polymerizations, alternative nitrile synthesis

**Text books**

**References**
4. Approaches to safe nanotechnology, Department of health and human services, DHHS (NIOSH) publication, 2009
5. www.foresight.org/UTF/Unbound_LBW/

**12NT206 NANOTOXICOLOGY AND ETHICS**

**Credits: 4:0:0**

**Objectives:**
- Awareness will be created on the toxicology of nanomaterials among students and the concept of sustainable nanotechnology will be introduced
- The adverse effect of nanoparticles interacting with biological membranes will be discussed. The ethical agenda to be followed in nanotechnology will be emphasized

**Outcome:**
- The student will understand the toxicology of nanomaterials and his/her responsibility when using nanotechnology

**Unit I**
**Nanotoxicology and Sustainable Nanotechnology:** Size-specific behavior of nanomaterials – nanotoxicology challenges – carbon nanotubes in practice – postproduction processing of carbon nanotubes – physicochemical properties of nanomaterials as mediators of toxicity – characterization of administered nanomaterials during toxicity studies – nanomaterial characterization after administration experiment

**Unit II**
**Nanoparticle Exposure:** Physicochemical determinants in particle toxicology – nanoparticles vs. micron-size particles – nanoparticle toxicity comparison to larger counterparts – requirement for appropriate model particles – exposure assessment, exposure pathways and their significance – documenting the occurrence and nature of exposures – bio-distribution of nanoparticles – localization of particles in tissues – relevance of drug targeting to nanotoxicology
Unit III

Unit IV
**Approaching the Nano-age Scientists as Moral Agents** – the business community and corporations as moral agents – policy makers and regulators as moral agents – ethical and societal implications – the public interface of science and human values – origins of the precautionary principle – the citizen as moral agent – the language of ethics – meta-ethics and normative ethics

Unit V
**The ethical agenda for nanotechnology**: The visions of nanotechnology – scenarios in the nanotech marketplace – clarifying purpose – the principle of respect for communities – the principle of the common good – the principle of social justice – utilitarian priorities The pressing questions – the players – the funders – the thinkers – the communicators – the arenas combined – the role of fore-sighting – ethics applied to the practical – citizenship in the nano-age – the value of the skeptical optimist

**Text Books:**

**Reference Books:**
1. Niosh, Approaches to Safe Nanotechnology, Department of health and human services, US, 2008

**12NT207 APPLICATIONS OF NANOTECHNOLOGY**

**Credits 3:0:0**

**Course Objective:**
- To learn the basic concepts of nanosciences and nanotechnology and their applications in various fields of science and engineering

**Course Outcome:**
• Students should be able to understand the basic concepts of nanosciences and nanotechnology and their applications in various fields of science and engineering

Unit I
Overview of Nanotechnology: Basic of Nanotechnology- Applications of nanotechnology- state of art of nanotechnology- relevance of nanotechnology- impact on economy and future development.

Unit II

Unit III

Unit IV
Nanotechnology in Engineering: Applications of nanotechnology in various fields of engineering-Development of sensors- devices-electronic devices- electromechanical devices-optoelectronic devices-computer memory-CPU etc.

Unit V
Nanotechnology in Biology: Applications of nanotechnology in biomedical fields- drug development and delivery-biomedical sensors- devices- development of biomaterials for tissue and bone replacement.

Text Books:

References:
3. Resources available in various national and international organizations.
4. www.nanohub.org
5. www.wikipedia.org
6. www.foresight.org/nano

12NT301 SYNTHESIS OF NANOMATERIALS AND CHARACTERIZATION LAB

Credit: 0:0:4

1. Synthesis of nanomaterials
   • Synthesis of Al2O3 nanoparticles
• Synthesis of strontium doped cerium oxide nanoparticles
• Synthesis of Magnetite nanoparticles (ferro fluid) by co-precipitation method
• Fabrication of nano silver coating on glass substrate
• Synthesis of NiO nanoparticles
• Synthesis of silver nanoparticles by chemical precipitation method
• Synthesis of gamma – ferric oxide (Meghemite) nanoparticles by simple low temperature route
• Synthesis of gold nanoparticles
• Synthesis of copper nanoparticles
• Preparation of CuO nanorods by wet chemical method

2. Characterization of nanoparticles
• XRD – crystalline structure, unit cell parameters, crystallite size & theoretical density measurements
• UV - comparison with standard data
• FTIR - comparison with standard data
• SEM - Microstructure determination
• TEM – Microstructure determination

12 experiments will be notified by HOD from time to time

12NT302 NANOELECTRONICS

Credits 4:0:0

Course Objective:
• To learn and understand basic and advanced concepts of nanoelectronics.

Course Outcome:
• To understand basic and advanced concepts of nanoelectronic devices, sensors and transducers and their applications in nanotechnology.

Unit I

Unit II

Unit III

Unit IV
**A Survey about the Limits – Replacement Technologies:** Energy and Heat dissipation – Parameter spread as Limiting Effect – Limits due to thermal particle motion – Reliability as limiting factor – Physical limits – Final objectives of integrated chip and systems.

Unit V

**Text Books**

**Reference Books**

**12NT303 NANOLITHOGRAPHY**

**Credits:** 4:0:0

**Course Objective:**
- To learn the basic concepts, methods, tools, applications and issues of lithography
- To study the advanced concepts and tools required for realizing and manipulating devices and nano-scale dimensions.

**Course Outcome:**
• Students should be able to understand the concepts involved in lithography and design lithographic masks for a given micro- and nano- devices and circuits.

Unit I
Introduction to Lithography: Introduction to lithography – Lithography process steps; Mask making, wafer pre-heat, resist spinning, pre-bake, exposure, development & rinsing, post-bake, oxide etching and resist stripping - Alignment marks in mask plate – Optical lithography – Light sources – Contact, proximity and projection printing and their modulation transfer function - Resolution in projection systems – Resists - Positive and negative photo resists and their comparison in terms of various parameters – Lift-off profile.

Unit II
Applications of Lithography: Application of lithography – Semiconductor IC fabrication – Fabrication of n-type/p-type MOSFETs using metal gate and self-aligned poly-gate with lithographic masks – Fabrication of CMOS FET using p-well and n-well process with lithographic masks – Fabrication of NPN and PNP BJT with lithographic masks – MEMS design flow - MEMS based pressure and acceleration sensor fabrication using lithographic masks – Advantages of scale-down approach in semiconductor ICs and MEMS sensors – Limitations of optical lithography.

Unit III

Unit IV

Unit V

Text Books

Reference Books
10NT304 NANOCOMPOSITES AND QUANTUM COMPUTATION

Credits: 4:0:0

Objectives:

• The student will learn newer concepts and current technology related to nanoscience
• The student will get an enthusiasm on getting involved in science of current importance.
• The influence of nanocomposites in newer materials becomes obvious to the students

Outcome:

• The student will get updated in knowledge of the current status of nanotechnology and gain knowledge on nanocomposites

Unit I

Unit II

Unit III

Unit IV

Unit V

Text Books:
2. Klaus Friedrich, Stoyko Fakivov, Zhony Shang, Polymer composites from nano to micro scale, Springer, USA, 2005

Reference Books:

12NT305 APPLICATIONS OF NANOTECHNOLOGY

Credits: 4:0:0

Objectives:
• The student will learn the advanced applications of nanotechnology

Outcome:
• The student will get updated in knowledge of the current status of nanotechnology and its applications

Unit I

Unit II

Unit III
Optical Data Storage: Write and read techniques (signal modulation, disk format, data reproduction), read and write principles (read-only, write-once, phase-change, magnetooptic
disks), optical pickup heads (key components, diffraction-limited laser spot, focusing and tracking error signals, servoloop design, actuator), optical media, near field optical recording, holographic data storage.

**Unit IV**


**Unit V**

**Nano Pharmaceuticals:** Generation and significance of Nano pharmaceuticals like nanosuspensions, nanogels, nanocarrier systems - Nano formulation – Nano encapsulation – Enhancement of drug therapy epitaxy

**Text Books**


**Reference Books**


**12NT306 INTRODUCTION TO NANOSTRUCTURED MATERIALS**

**Credit 4:0:0**

**Course Objective:**
- To acquire the fundamental knowledge about nanostructured materials
- To understand about the characterization techniques used for characterizing the nanomaterials

**Course Outcome:**
- The students should be able understand basic and advanced synthetic methodologies
- The techniques used for nanomaterials preparations
Unit I

Unit II

Unit III

Unit IV:

Unit V

Text Books

Reference Books

12NT307 SYNTHETIC METHODOLOGIES FOR NANOMATERIALS

Credits 4:0:0

Course Objective:
- To learn and understand basic and advanced concepts Nanomaterials preparations
- To understand the various synthetic techniques and methodologies used for nanomaterials preparations.
Course Outcome:
- To understand the basic and advanced synthetic methodologies
- To study the techniques used for nanomaterials preparations.

Unit I

Unit II
CNTs and other Nanomaterials: Types of CNTs – preparation of CNTs – arc discharge method – laser ablation method – chemical vapour deposition process – nanotubes made up of metal (silver), metal nitride (SiN), ceramic oxides (ZrO₂, TiO₂) and metal chalcogenides (S, Se, Te systems) – electrospinning of polymers – nanorods made up of metal (Sn) and semiconductors (ZnO, CdS) – nanosprings – nanorings – ion beam induced nanostructures – atom beam sputtering.

Unit III

Unit IV

Unit V

Text Books

Reference Books

12NT308 - BIOLOGY FOR NANOTECHNOLOGY

Credit 4:0:0

Course Objective:
- To acquire the basic knowledge about animal and plant cells
- To understand about molecular targets

Course Outcome:
- The students should be able understand basic biology
- Nanotechnology applications in biological systems

Unit I
Cell Biology & Tissue Culture
Structure and organization of prokaryotic and eukaryotic cell (animal cell & plant cell), tissues and organs, cell and tissue culture – application of plant transformation for productivity and performance, animal cell culture technology – applications of animal cell culture – stem cell culture, artificial organ synthesis

Unit II
Molecular Biology

Unit III
Genetic Engineering

Unit IV
Immunology
Cells and organs of immunity, types of innate and acquired immunities, antigen, antibody structure and its types, humoral immunity, cell mediated immunity, introduction to complement system – MHC & graft transplantation and graft rejection.

Unit V
Nanoparticles in Biology
Biosynthesis of nanoparticles, microbial nanoparticle production, biomineralization, magnetosomes, nanoscale magnetic iron minerals in bacteria, virus & fungi. DNA based nanostructures, protein based nanostructures.
Text Books

Reference Books

12NT309 ENGINEERING PRINCIPLES FOR NANOTECHNOLOGY

Credits 4:0:0

Course Objective:
- To learn and understand basic and advanced concepts of engineering principles for nanotechnology:

Course Outcome:
- The students should be able to understand basic and advanced concepts engineering principles in nanotechnology applications.

Unit I
Thin Film Coating: Electro plating, Electroless plating, Langmuir-Blodget (LB) films, Thermal growth, Chemical Vapour Deposition (CVD), Sputtering deposition, molecular beam epitaxy atomistic nucleation process, cluster coalescence and deposition, amorphous thin films.

Unit II

Unit III
Vacuum Technology: Introduction- Pump selection and exhaust handling, rotary oil pumps, roots pump, diffusion pumps, turbo-molecular pump, cryo pump, sputter-ion pump, pressure measurements, thermodynamics of evaporation, evaporation rate, alloys, compounds, sources, transport and deposition monitoring.

Unit IV
Unit V
Silicon Technology: Semiconductor as base material- band diagram of semiconductor- band diagram of inhomogeneous semiconductor- different types of components in semiconductor, different types of transistor integration- technological processes for microminiaturization methods and limits of microminiaturization in silicon.

Text Books

Reference Books

12NT310 SYNTHESIS OF NANOMATERIALS (LAB)
Credits 0:0:4

Course Objective:
• To synthesize nanomaterials by various chemical and physical routes

Course Outcome:
• The student will understand the methodology of synthesizing nanomaterials by different processes and techniques.

12 experiments will be notified by the HOD from time to time

List of Experiments:
1. Synthesis of Alumina (Al₂O₃) nanoparticles
2. Synthesis of MgAl₂O₄ nanoparticles
3. Synthesis of CeₓSrₓO₂₋δ nanoparticles
4. Synthesis of nano BaCeO₃ powder
5. Synthesis of γ- LiAlO₂ nanoparticles
6. Synthesis of Magnetite Nanoparticles (Aqueous Ferro fluid)
7. Synthesis of Nickel Oxide nanoparticles by chemical precipitation method
8. Synthesis of silver nanoparticles by chemical reduction method
9. Chemical Synthesis of MgO nanoparticles
10. Preparation of CuO nanomaterials by wet chemical method
11. Synthesis of Cadmium sulphide nanocrystals
12. Preparation of Barium Sulphate nanocrystals by aqueous colloidal method
13. Preparation of CuO nanorods using Ultrasonic bath
14. Synthesis of gold nanoparticles by simple chemical reduction method
15. Preparation of Fe₂O₃ nanoparticles by new sol-gel method
16. Preparation of polymeric nanofibers
12NT311 FABRICATION AND IMAGING TECHNIQUES FOR NANOTECHNOLOGY

Credit 4:0:0

Course Objective:
- To acquire knowledge about general nanofabrication techniques
- To understand the concepts of spectroscopy techniques
- To know the mechanical methods of characterizing nanomaterials
- To study the x-ray related techniques used for characterizing the nanomaterials

Course outcome:
- To understand the basics of image processing techniques
- Basic and advanced synthetic methodologies using imaging techniques

Unit I
General Fabrication Techniques: Key challenges and barriers for nanocharacterization - Photolithography – Cleaning / etching – Oxidation - oxides – Gettering – doping – Epitaxy. Top-down techniques – Other optical lithography’s (UV, X-ray, and LIL) – Particle beam lithography’s (e-beam, FIB, shadow mask evaporation) – Probe lithography. – Ball milling- Bottom up approach – Chemical routes – Wet chemical routes, Chemical Vapor Deposition (CVD), Chemical reduction process, metal oxide formation.

Unit II

Unit III
Probing Techniques and Magnetometer: Scanning electron microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Tunneling Microscopy (STM), Atomic force microscopy (AFM), Near field scanning optical microscopy (NSOM) - Vibrating sample magnetometry (VSM), EPR, Mossbauer spectroscopy.

Unit IV

Unit V
Text Books

Reference Books

12NT312 THERMODYNAMICS AND QUANTUM MECHANICS FOR NANO SCALE SYSTEMS
Credits 4:0:0

Course Objective:
• To learn and understand basic and advanced concepts of thermodynamics, statistical mechanics and quantum mechanics in the perspective nanoscale systems.

Course Outcome:
• The students should be able to understand the basic and advanced concepts to analyze the nanoscale systems

Unit I

Unit II

Unit III

Unit IV
Electrical and Magnetic Properties: Electronic and electrical properties-One dimensional systems-Metallic nanowires and quantum conductance - dependence on chirality -Quantum dots
- Two dimensional systems - Quantum wells and modulation doping - Resonant tunnelling - Magnetic properties Transport in a magnetic field - Quantum Hall effect - Spin valves - Spin tunneling junctions - Domain pinning at constricted geometries - Magnetic vortices.

**Unit V**

**Mechanical and Optical Properties:** Mechanical properties - Individual nanostructures - Bulk nanostructured materials - Ways of measuring - Optical properties - Two dimensional systems (quantum wells) - Absorption spectra - Excitons - Coupled wells and superlattices - Quantum confined Stark effect.

**Text Books**

**Reference Books**
2. M.C. Gupta, Statistical Thermodynamics.

**12NT314 ADVANCED EXPERIMENTS AND SIMULATION TECHNIQUES FOR NANOPARTICLE CHARACTERIZATION**

**Credits:** 0:0: 4

**Course Objective:**
- To learn and have hand-on experience with advanced nanotechnology characterization techniques

**Course Outcome:**
- The students should be able to handle the characterization tools independently and analyze the data using technical software.

**Experiment details**
1. Greener synthesis of nanoparticles and its optical characterization using UV-Vis Spectroscopy
2. Characterization of Magnetite and Alumina nanoparticles using X-ray Diffraction
3. Surface Morphological study of nanomaterials using SEM (Scanning Electron Microscope)
4. Photoluminescence studies of nanomaterials
5. Analysis of nanoparticles and nano thin films by Atomic Force Microscopy
7. Synthesis of nanoparticles and its characterization using Particle Size Analyzer.
8. Preparation characterization of polymer nanocomposite membrane
9. Characterizations of Ball Milled nanoparticles
10. I-V studies of nanomaterials.
11. Molecular Simulation
12. Molecular Dynamic Simulation
12NT316 NANOTECHNOLOGY FOR ADVANCED DRUG DELIVERY SYSTEMS

Credits: 4:0:0

Course Objective:
- To learn and understand basic and advanced concepts of nanotechnological drug delivery systems.

Course Outcome:
- The students should be able to understand various methods of nanotechnological drug delivery systems.

Unit I
Principles of Drug Delivery Systems: Modes of drug delivery, ADME hypothesis-controlled drug delivery, site specific drugs, barriers for drug targeting, passive and active targeting, Strategies for site specific, time and rate controlled delivery drugs, antibody based and metabolism based targeting.

Unit II

Unit III

Unit IV

Unit V
Nanoparticle and Targeted Systems for Cancer Diagnosis and Therapy: Targeted delivery through enhanced permeability and retention, Folate receptors, Targeting through angiogenesis, Targeting to specific organs or tumour types, Tumour specific targeting: Breast cancer, Liver targeting tumour, vasculature for imaging, Delivery of specific anticancer agents: such as Paclitaxel, Doxorubicin, 5-Fluorouracil etc.

Text Books
Reference Books

12NT317 EXPERIMENTAL TECHNIQUES FOR NANOBIO TECHNOLOGY

Credits 0:0:4
Course Objective:
- To learn and have hand-on experience with the synthesis of nanobiomaterials and relevant characterization techniques.

Course Outcome:
- The students should be able to handle the experiments tools independently and synthesize the nanobiomaterials.

Experiments
1. Isolation of Genomic DNA from Plant Tissue
2. Isolation of Genomic DNA from Animal Tissue
3. Digestion of Plasmid DNA & Testing with Agarose gel Electrophoresis
4. Ligation of fragmented Plasmid DNA
5. Liposomes for Drug Delivery
6. Antimicrobial Activity of Microdiscs
7. Antimicrobial Activity of Zero Valent Iron Nanoparticles
8. Sodium Alginate Nanospheres
9. Microspheres for Drug Delivery
10. Determination of Drug loading in Nanosphere
12. PCR (Polymerase Chain Reaction) Amplification of DNA

12NT318 INTERMOLECULAR AND SURFACE FORCES IN NANOTECHNOLOGY APPLICATIONS

Credits 4:0:0

Course Objective:
- To learn the basic concepts of intermolecular forces, surface forces and contact forces
- To study advanced concepts of these forces in nanotechnology applications.

Course Outcome:
- Students should be able to understand the concepts of intermolecular forces, surface forces and contact forces and analyze effects these forces in nanotechnology applications.

Unit I:
intermolecular forces: covalent and coulomb interactions-charge-charge interactions-self-energy-Born energy of an ion.

Unit II

Unit III
Forces between Particles and Surfaces: Van der Waal’s force between surfaces- Hamaker constant-molecule-surface, surface surface for different geometries: sphere-sphere, sphere-plane, plane-plane, cylinder cylinder- Electrostatic forces between surfaces –electric double layer-Poisson-Boltzman (PB) equation- surface charge- electric field –counter ion concentration- PB Limitations- Deby length- DLVO forces. Non-DLVO forces-solvation-structural-hydration forces hydrophobic- hydrophilic interactions-steric and fluctuation forces

Unit IV

Unit V
Applications in Nanotechnology: Nanoparticles, problem of agglomeration and clusters in nanoparticles and Geeko Feet adhesion, NEMS- MEMS adhesion.

Text Books

Reference Books

12NT319 NANO BIOMATERIALS

Credit 4:0:0

Objectives:
• To acquire knowledge about polymeric implant materials
• To know the role of biomaterials for implant coating

Outcome:

• To understand the concepts of cardiovascular implants
• To know the basics of biopolymers and tissue engineering

Unit I
Polymeric Implant Materials: Classification of biomaterials, Polyolefin; polyamides (nylon); Acrylic polymers (bone cement) and hydrogels; Fluorocarbon polymers; Natural and synthetic rubbers, silicone rubbers.

Unit II

Unit III
Cardiovascular Implants: Role of nanoparticles and nanodevices in Blood clotting; Blood rheology; Blood vessels; Geometry of blood circulation; Vascular implants; Cardiac pacemakers; Blood substitutes; Biomembranes, Ophthalmological applications of nano biomaterial.

Unit IV

Unit V

Text Books
2. K. K. Jain, ‘Nanobiotechnology Molecular Diagnostics: Current Techniques and Applications (Horizon Bioscience)’, Taylor & Francis, 2006

Reference Books
2. Robert W. Kelsall and Ian W. Hamley, Mark Geoghegan, Nano Scale Science and Technology, John Wiley, 2005

12NT320 NANOBIO TECHNOLOGY

Credits: 4:0:0

Course Objectives:

• To know about biology inspired concepts, nanobiome metrics, natural nanocomposites, nano analytics and molecular manufacturing

Outcome:

• Students acquire a good understanding on the basic principles and applications of nanobiotechnology

Unit I


Unit II

Nano Biome trics-introduction-lipids as nanobricks and mortar, self assembled nanolayersthe bits that do think-proteins-three dimensional structures using a 20 aminoacid-biological computing-a protein based 3D optical memory using DNA to build nano cubes and hingesDNA as smart glue-DNA as wire template-DNA computers.

Unit III

Natural Nanocomposites-introduction-natural nano composite materials-biologically synthesized nanostructures-biologically derived synthetic nanocomposites-protein based nanostructure formation-biologically inspired nanocomposites-nanotechnology in Agriculture [Fertilizers and Pesticides].

Unit IV


Unit V

Molecular Manufacturing-Nano simulation, implications of nanotechnology, health and safety implications from nanoparticles. Health issues-Environmental issues-need for regulation-social implications, possible military applications-potential benefits and risks for developing countries-studies on the implications of nanotechnology

Text Books:
2. Tuan Vo-Dinh, Protein Nanotechnology Protocols, Instrumentation and Application, Series ; Methods in Molecular Biology (2005)

Reference Books:

12NT321 NANOCOMPOSITES

Credits 4:0:0

Course Objective:
• To learn and understand structure - property correlation of various nanocomposites.

Course Outcome:
• The students should be able to understand the structure-property relations of various nanocomposites used for engineering and biomedical applications.

Unit I

Unit II

Unit III

Unit IV
Unit V


Text books

Reference books

12NT322 NANOSENSORS AND TRANSDUCERS

Credits 4:0:0

Course Objective:
- To learn and understand basic and advanced concepts of nano-sensors and transducers for nanotechnology applications:

Course Outcome:
- The students should be able to understand nano-sensors and transducers used in nanotechnology applications.

Unit I


Unit II

Unit III

Unit IV

Unit V:
Signal Conditioning and Data Acquisition: Earthing and grounding – series and common mode noise – errors due to common mode interference – specification of common mode rejection ratio– instrumentation amplifiers –Edge triggered PSD) – Phase locked loop.

Text Books

Reference Books

12NT323 INDUSTRIAL NANOTECHNOLOGY
Credits 4:0:0

Course Objective:
• To learn and understand basic and advanced concepts of industrial nanotechnology.

Course Outcome:
• The students should be able to understand industrial nanotechnology devices, sensors and transducers and their applications

Unit I
Overview of Information Storage and Nanotechnology: Different types of information storage materials and devices: solid state memory, optical memory, magnetic recording, emerging technologies, role of nanotechnology in data storage.
Unit II
**Optical Data Storage:** Write and read techniques (signal modulation, disk format, data reproduction), read and write principles (read-only, write-once, phase-change, magneto-optic disks), optical pickup heads (key components, diffraction-limited laser spot, focusing and tracking error signals, servo-loop design, actuator), optical media, near field optical recording, holographic data storage.

Unit III

Unit IV

Unit V
**Industrial Applications of Nanomaterials:** Nanoparticles and Micro–organism, Nanomaterials in bone substitutes & Dentistry, Food and Cosmetic applications, Textiles, Paints, Catalysis, Drug delivery and its applications, Biochips- analytical devices, Biosensors.

Text Books
3. R. Waser, Nanoelectronics and Information Technology, John Wiely and sons publication, 2003

Reference Books

**12NS202 ELEMENTARY MATHEMATICS**

**Credit:** 4:0:0

**Course Objective:**
- To understand the general formulation of Mathematics
- To solve equations for specific physical problems

**Course Outcome:**
• To improve mathematical skills necessary to solve differential equations and Integral equations.

Unit I
Differential Calculus: Curvature in Cartesian coordinates and polar coordinates – circle of curvature – evolutes and envelopes – maxima and minima of functions of two variables (proof of theorems not included)

Unit II
Integral Calculus: Double integrals – change of order of integration – triple integrals (problems involving Jacobians are not included).

Unit III

Unit IV
Differential Equation: First order linear differential equations – second and higher order linear differential equations with constant coefficients with RHS of the form e(ax), x(n), sin (ax), cos (ax), e(ax) f(x), x f(x) where f(x) is sin (ax) or cos (bx) – differential equations with variable coefficients (Euler’s form) – Simultaneous equations – method of variation of parameters.

Unit V
Beta and Gamma Integrals: Beta and Gamma integrals – Relation between them – properties – evaluation of definite integrals in terms of beta and gamma functions simple application.

Text Books

Reference Books

12NS203 ENGINEERING PHYSICS

Credits: 4:0:0

Course Objective:
• To have a basic knowledge about physics and its fundamental concepts.

Course Outcome:
• Students would be able to understand the basic concepts of physics particularly about the band theory of solids, Electrostatics fundamentals, and gravitation principles, thermodynamics basics, and photoconductivity, photovoltaic principles and nuclear physics.
• This course will give the students the broad knowledge on various fields in physics.

Unit I

**Band Theory of Solids:** Origin of energy bands, Kronig-Penny model (qualitative), E-K diagrams, Brillouin Zones, concept of effective mass and holes. Classification of solids into metals, semiconductors and insulators. Fermi energy and its variation with temperature. Hall Effect and its applications.

Unit II

**Electrostatics:** Revision of electrostatics, Applications of Gauss law for various symmetric situation, electric potential equi-potential surfaces, dipole, potential calculation in simple cases. Ohm’s Law, Biot-Savart Law, Ampere’s law and its applications, Lorentz force, cyclotron motion, magnetic force on a current carrying wire, Torque on a current.

Unit III

**Gravitation & Thermodynamic:** Law of gravitation, Kepler’s laws, Oscillatory motion, Free harmonic oscillations, damped harmonic motion, forced oscillations and resonance, Concept of temperature and its measurement, heat and work, First law of thermodynamics, Second law of thermodynamics Carnot engine and cycle, isothermal and adiabatic processes, enthalpy and concept of entropy.

Unit IV

**Photoconductivity and Photovoltaics:** Photo conductivity in insulating crystal, variation with illumination, effect of traps, application of photoconductivity, photovoltaic cells, solar cell and its characteristics.

Unit V

**Nuclear Physics:** Structure of Nucleus, Binding energy curves of various elements, fission, fusion, effects of nuclear radiation, optical, microwave radiation, absorption, penetration, energy density, biological half life, interaction of radiation with living matter, isotopes used in biology and medicines.

**Text Books**

**References Books**
Course Objective:
- To understand the basic principles of chemistry
- To provide fundamental insight into the macroscopic world of materials.

Course Outcome:
- To acquaint students with these basic principles
- To help students learn to apply these principles broadly and effectively.

Unit I

Unit II

Unit III

Unit IV

Unit V
specific and general catalysis – catalytic constants – Bronsted relationship – Hammett acidity functions.

**Text Books:**

**Reference Books:**

12NS205 ELEMENTARY BIOLOGY

**Credit:** 4:0:0

**Course Objective:**
- To understand the basic principles of biology
- To provide fundamental insight into the bio world of materials.

**Course Outcome:**
- To acquaint students with these basic principles
- To help students learn to apply these principles broadly and effectively.

**Unit I**

**Unit II**
acids: Structure of purines, pyrimidines, nucleosides and nucleotides. Structure, types and biological role of RNA and DNA.

Unit III

Unit IV

Unit V

Text Books
Reference Books

12NS206 BASIC ELECTRONICS

Credit: 4:0:0

Course Objective:
• To know the basics about semiconductor, integrated circuits and communication system.

Course Outcome:
• Students will get overview about the basics of electronics.

Unit I
Introduction to Semiconductor: Covalent bond – N type & P type semiconductor – conduction in semiconductor – semiconductor device: diode, transistor, FET, MOSFET, UJT.

Unit II

Unit III
Digital Systems: Number system – Boolean algebra – logic gates –truth table - combinational circuit -4 x 1 multiplexer – 1 x 4 demultiplexer - digital computer principles.

Unit IV
Communication: Basic block of communication system – need for modulation – Derivation of AM and FM signal - Amplitude and Frequency Modulation (Balanced modulator and varactor diode modulator)- Demodulation(AM diode detector and balanced slope detector.

Unit V
Communication Systems: Block diagram of AM and FM transmitter - Superheterodyne receiver – satellite communication – Fibre optic communication

Text Books

Reference Books
12NS207 SOLID STATE PHYSICS

Credit: 4:0:0

Course Objective:
• Get knowledge on band theory of solids
• Understand theoretical aspects of dielectric magnetic and optical properties of solids
• Gain knowledge on the principle of super conductivity

Course Outcome:
• Students will be able to apply the theory of solids to solve practical problems

Unit I

Unit II

Unit III

Unit IV

Unit V

Text Books

Reference Books
12NS208 QUANTUM MECHANICS

Credit: 4:0:0

Course Objective:

- To understand the general formulation of quantum mechanics
- To solve Eigen value equations for specific physical problems
- To get knowledge on the theoretical aspects of perturbation of atoms due to electric and magnetic fields
- To understand the theory of many electron systems

Course Outcome:

- Improved mathematical skills necessary to solve differential equations and Eigen value problems using the operator formalism
- Quantum mechanical solution of simple systems such as the harmonic oscillator and a particle in a potential well.
- Solutions to perturbation problems and many electron systems

Unit I

Unit II

Unit III

Unit IV
Unit V

Text Books
2. G. Aruldhas, Quantum Mechanics , Prentice Hall of India 2006

Reference Books
2. L.I Schiff , Quantum Mechanics, McGraw Hill, 1968

12NS210 SOLID STATE CHEMISTRY
Credit: 4:0:0

Course Objective:
- To teaches basic principles of Solid state chemistry and physics
- To understand the how they apply in describing the behavior of the solid state.
- To study the relationship between electronic structure, chemical bonding, and crystal structure is developed.

Course Outcome:
- The student should be conversant with the Solid state of material
- To understand the Principles of characterization of the materials
- To understand the basic of bonding principles and formation process

Unit I

Unit II

Unit III
Solid State Reactions: Types; sintering; nucleation; Factors influencing the reactivity of solids; Precursors to solid state reactions; Tammann and Hedvall mechanism; Wagner’s diffusion theory of reaction; Material transport in solid state reaction—counter diffusion, Kirkendall effect;
Huttig’s mechanism; Kinetic model: Reaction in powder compact, parabolic rate law, Jander’s rate equation.

**Unit IV**

**Chemical Kinetics and Phase diagram:** Rate of reaction, Order and molecularity, integrated rate equation. Half life, Pseudo first order reaction, temperature dependence of rate of reactions. Theory of reaction rates: Collision theory, Arrhenius equation. Definition of terms: Phase, component, degree of freedom or varions, Phase rule: Advantages, limitations, Phase diagram, One component system: Water and Sulphur system, Two component styste: Solid – Liquid equilibrium, Eutectic and Eutectoid system.

**Unit V**

**Liquids, Solution and Redox reaction:** Solubility rules, Acids, Bases, pH, pK_a, pK_b, Buffers, concepts, Henderson equations, Oxidation reduction reaction.

**Text Books**


**Reference Books**


12NS211 MATERIALS SCIENCE ENGINEERING

**Credits: 4:0:0**

**Course Objective:**
- To understand of mechanics, physical and chemical properties of materials

**Course outcome:**
- To apply the basic principles of Materials for Science and Engineering applications

**Course Outcome:**
- The student should be conversant with the material Science
- To understand the Principles of Cauterization of the materials

**Unit I**

Unit II

Unit III
**Diffusion mechanism:** Diffusion mechanisms. Steady and non-steady state diffusion. Factors that influence diffusion. Non-equilibrium transformation and microstructure, Fick's laws and application of diffusion in sintering, doping of semiconductors and surface hardening of metals.

Unit IV
**Application and Processing:** Types of metals and alloys, Fabrication of metals, Thermal processing of metals, Heat treatment, Precipitation hardening. Types and applications of ceramics-Fabrication and processing of ceramics. Mechanical behavior of polymers-Mechanisms of deformation and strengthening of polymers. Crystallization, melting and glass transition- Polymer types- Polymer synthesis and processing. Particle reinforced composites - Fiber reinforced composites- Structural composites.

Unit V

**Text Books**

**Reference Books**
3. V. Gerold, Materials Science and Technology, Volume 1, VCH Publication.(1992)

**12NS212 LABORATORY WORK FOR NSNT**
(PHYSICS, CHEMISTRY, BIOLOGY, COMPUTATIONAL AND NANOTECHNOLOGY)

**Credits:** 0:0:4

**Course Objective:**
- To synthesize nanomaterials by various chemical and physical routes.
Course Outcome:
- To understand the methodology of synthesizing nanomaterials by different processes and techniques.

List of Experiments:
1. Synthesis of TiO$_2$ nanoparticles by sol-gel method
2. Synthesis of ZnO nanoparticles using chemical method
3. Synthesis of Ce$_{1-x}$Sr$_x$O$_{2-\delta}$ nanoparticles
4. Synthesis of nano BaCeO$_3$ powder
5. Synthesis of γ- LiAlO$_2$ nanoparticles
6. Synthesis of Magnetite Nanoparticles (Aqueous Ferro fluid)
7. Synthesis of Nickel Oxide nanoparticles by chemical precipitation method
8. Synthesis of silver nanoparticles by chemical reduction method
9. Chemical Synthesis of MgO nanoparticles
10. Preparation of CuO nanomaterials by wet chemical method
11. Synthesis of Cadmium sulphide nanocrystals
12. Preparation of Barium Sulphate nanocrystals by aqueous colloidal method
13. Preparation of CuO nanorods using Ultrasonic bath
14. Synthesis of gold nanoparticles by simple chemical reduction method
15. Preparation of Fe$_2$O$_3$ nanoparticles by new sol-gel method

12 experiments will be notified by the Lab supervisor/HOD time to time
LIST OF SUBJECTS

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12NT328  RESEARCH METHODOLOGY IN NANOTECHNOLOGY

Credits: 4:0:0

Objective:
- Awareness will be created on the research methodology in nanotechnology among research scholars/students and the concept of sustainable nanotechnology will be introduced.
- The student will get clear exposure on research techniques based on spectroscopic and other instrumentation methods.

Outcome:
- The student will understand the concepts of research methodology in nanotechnology and its related techniques.

Unit I
RESEARCH METHODOLOGY: Problem Identification and survey design, hypothesis generation and testing: collecting evidences and notion based correlation, survey literature and design, scope for the hypothetical problem and its formulation, designing and planning of research tools and experimentation, preparation of synopses, work plan and data collection, data processing using qualitative and quantitative analytical/statistical approaches, writing of abstracts, research projects, reports, papers, dissertation and thesis, (Formatting and submission of on-line manuscripts). General idea of seminars, symposia, workshops and conferences. Planning and making deliberations, General idea about impact factor of journals, IPR and patents.

Unit II
QUANTITATIVE APPROACHES IN RESEARCH METHODOLOGY: Statistical tools and approaches, testing confidence limits, normal binomial and Poisson distribution, method of least square and successive approximation, correlation and regression – Linear and non linear; multiple variable matrix and its analysis, drawing of good fit lines, slopes, correlation coefficients and their significance.

Unit III

Unit IV
Unit V

INSTRUMENTATION: Thermo gravimetric analytical (TGA) methods - characteristic features of thermogram - instrumentation of thermogravimetry - factors affecting TGA - applications of TGA - DTA - characteristic of DTA curves - instrumentation of DTA - factors affecting DTA - applications of DTA. XRD - a brief account of the principles of molecular structure determination by X-ray diffraction by single crystal - structure factor - Biology instrument testing - antimicrobial assay - ultra centrifuge - cell culture - cytotoxicity measurement.

Text Books

Reference Books
13NT201 INTRODUCTION TO NANOTECHNOLOGY INVENTIONS AND PATENTS

Credit 3:0:0

Objective:
• To learn about the latest nanotechnology inventions and current nanotechnology patents

Outcome:
• Students should be able to comprehend and analyze pros and cons of the nanotechnology inventions, innovations and patents

Unit I
OVERVIEW OF NANOTECHNOLOGY INVENTIONS AND PATENTS

Unit II
NANOTECHNOLOGY INVENTIONS AND PATENTS IN EVERYDAY LIFE

Unit III
NANOTECHNOLOGY INVENTIONS AND PATENTS IN SCIENCES
Basic of inventions and patents in sciences, concepts of converting knowledge into patents. Case study of a invention in science. Case study of a patent in general science.

Unit IV
NANOTECHNOLOGY INVENTIONS AND PATENTS IN ENGINEERING
Important nanotechnology inventions and patents in engineering, case study of a invention and a patent in each branch of engineering, NEMS/MEMS, Microprocessors, devices and sensors. Pros and cons of a existing patent (Mechanical engineering, Electrical engineering, Computer engineering)

Unit V
NANOTECHNOLOGY INVENTIONS AND PATENTS IN BIOMEDICAL ENGINEERING
Important nanotechnology inventions and patents in biomedical engineering, case study of a patent and invention in biomedical engineering, cancer treatment and targeted drug delivery patents. Pros and cons of a existing patents.

Text Books
1. Mark Ratner and Daniel Ratner, Nanotechnology: A gentle introduction to the next big idea.
   Pearson Education Inc., 2003, Prentice Hall/PTR, New Jersy, USA

Reference Books
   2nd ed., 2007