**NOORUL ISLAM CENTRE FOR HIGHER EDUCATION**

**NOORUL ISLAM UNIVERSITY, KUMARACOIL**

**DEPARTMENT OF NANOTECHNOLOGY**

**M.TECH NANOTECHNOLOGY**

**CURRICULUM & SYLLABUS**

**SEMESTER – I**

| SL. NO | COURSE CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| **THEORY** | | | | | | |
| 1 | MA1501 | Advanced Mathematics | 3 | 1 | 0 | 4 |
| 2 | NT1501 | Concepts of Classical, Statistical and Quantum Mechanics | 3 | 0 | 0 | 3 |
| 3 | NT1502 | Introduction of Nanoscale science & Technology | 3 | 0 | 0 | 3 |
| 4 | NT1503 | Synthesis of Nanomaterials | 3 | 0 | 0 | 3 |
| 5 | NT1504 | Biomaterials | 3 | 0 | 0 | 3 |
| 6 | NT15E1 | Elective I: | 3 | 0 | 0 | 3 |
| **PRACTICAL** | | | | | | |
| 7 | NT1571 | Synthesis and Preparation of Nanomaterials – Laboratory | 0 | 1 | 2 | 2 |
| **TOTAL** | | | 18 | 2 | 2 | 21 |

**MA1501 ADVANCED MATHEMATICS**

| L | T | P | C |
|---|---|---|---|
| 3 | 1 | 0 | 4 |

**AIM:**

To gain a well found knowledge of optimizing a function and variational problems which provide necessary mathematical support and confidence to tackle real life problems.

**OBJECTIVE:**

The course objective is to extend the ability of the students in the areas of Matrix Theory and Stochastic Processes. This will be applicable in Engineering practices and serve as a pre-requisite for higher studies and research.

**UNIT I ADVANCED MATRIX THEORY 9**

Generalised Eigen vectors– Jordan canonical form — Matrix norms – Singular value decomposition – Pseudo inverse – Least square approximations – QR algorithm.

**UNIT II SPECIAL FUNCTIONS 9**

Bessel's equation – Bessel function – Recurrence relations - Generating function and orthogonal property for Bessel functions of first kind – Fourier-Bessel expansion.

**UNIT III RANDOM PROCESSES 9**

Classification – Stationary random processes – Ergodic process - Auto correlation – Cross correlations – Properties - Power spectral density.

**UNIT IV DYNAMIC PROGRAMMING 9**

Bellman’s principle of optimality – Characteristics of the dynamic programming model – The recursive equation approach – Solution of discrete dynamic programming problem.

**UNIT V CALCULUS OF VARIATIONS 9**

Euler’s equation – Functional dependent on first and higher order derivatives – Functional dependent on functions of several independent variables -Isoperimetric Problems.

**L: 45 + T: 15, TOTAL: 60 PERIODS**

**REFERENCES:**


1. Bronson, R., “Matrix Operations”, Schaum’s Outline Series, McGraw–Hill, New York
2. Gupta, A.S., “Calculus of Variations with Applications”, Prentice-Hall of India, New Delhi.
3. Dr.Venkataraman, M.K., “ Higher Mathematics for Engineering and Science”, National Publishing Company.1992.
4. Taha, H.A., “Operations Research – An Introduction”, Sixth Edition, Prentice-Hall of India, New Delhi.
5. Gupta, P.K. and Hira, D.S., “Operations Research”, S.Chand & Co. New Delhi.
6. Peebles Jr., P.Z., “Probability, Random Variables and Random Signal Principles”, McGraw-Hill Inc..

| NT1501 | CONCEPTS OF CLASSICAL, STATISTICAL AND QUANTUM MECHANICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**AIM**

To study the behavior of matter and energy in everyday universe and especially at small scale. To develop an understanding of the physical theories before becoming involved in the mathematical procedures.

**OBJECTIVE**

The objective of this course is to understand the basic mechanical problems, the motion of particles in the classical as well as atomic scale, how the properties of macroscopic bodies arise as suitable mean of the properties of the microscopic states. The student will analyze the interaction between atoms and elementary particles.

**UNIT I** **9**

Basic Principles of Classical Dynamics – Foundation of Mechanics - Conservation laws for n bodies: Conservation of Linear Momentum, Conservation of Angular Momentum, Conservation of Energy - Degrees of Freedom - Generalized co-ordinates – Limitations of Newton's Law - Euler-Lagrangian Differential Equation - Hamiltonians Variation Principle.

**UNIT II** **9**

Foundation of Statistical Mechanics and Thermodynamics: Phase space – Ensembles: Types of Ensembles – Micro canonical Ensembles, Canonical Ensembles, Grand canonical Ensembles - Uses of Ensembles – Classical Distribution Law: Microstates and Microstates – Sterling's approximation - Maxwell-Boltzman distribution law - Bose-Einstein distribution law - Fermi-Dirac distribution law – Comparison of the three distribution laws.

**UNIT III** **9**

Basis of Quantum Physics – De Broglie's concept – Operators – Bra and Ket notation- Physical interpretation of wave function – Normalized and orthogonal wave function - Heisenberg's Uncertainty Principle – Statement and illustrations. Electronic phenomena in nanostructures. Electronic energy states in quantum confined systems. Semiconductor heterojunctions.2-DEG systems, Quantum Dots, tubes and wires, Electronic states in Quantum dots.

**UNIT IV** **9**

Linear Harmonic oscillator – Operator Method - Hydrogen atom – Solution of radical Equation – Energy Eigen value - Angular momentum – Total angular momentum operators – Commutation relationship with components - Addition of angular momentum (Elementary ideas only)

**UNIT V** **9**

WKB approximation – variational method – Ground state Helium – Scattering – Differential Scattering – Scattering cross-section - Stationary scattering wave – Scattering amplitude

**TOTAL: 45 PERIODS**

**REFERENCES**


1. Quantum Mechanics – Satya Prakash and C. K Singh Kedar Nath and Ram Nath Co.
2. Quantum Mechanics – G. Aruldhas – Prentice Hall of India, New Delhi.
3. Classical Mechanics, by L.S. Gupta, V. Kumar, and H.V. Sharma, Pragati Prakashan Publication, 2007.
4. Statistical Mechanics, by Gupta and Kumar, Pragati Prakashan Publication.
5. Modern Physics, by R. Murugeshan, Ninth Edition.
6. Classical Mechanics, by H.Goldstein, Addison Wesley.
7. Classical Mechanics, N.C. Rana and P.S. Joag, Tata Mc Graw Hill, 1991.


| NT1502 | INTRODUCTION TO NANOSCALE SCIENCE AND TECHNOLOGY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**AIM:**

To learn the basic concepts of nanoscale phenomena at the atomic and molecular scale.

**OBJECTIVE:**

The objective of this course is to know the revolutions behind nanotechnology and nanomachines. The student will be clear about the aspects of intermolecular forces, various properties and other phenomena seen in the nanomaterials.

**UNIT I** **9**

Background to nanotechnology - scientific revolutions – types of nanotechnology and nano machines – atomic structure – molecules & phases – energy – molecular and atomic size – surfaces and dimensional space – top down and bottom up. Misnomers and misconception of Nanotechnology.

**UNIT II** **9**

Basic problems and limitations - opportunities at the nanoscale – time and length scale in structures – energy landscapes – basic intermolecular forces interdynamic aspects of intermolecular forces. Evolution of Band structures and Fermi surface.

**UNIT III** **9**

Definition of a nano system -dimensionality and size dependent phenomena; Quantum dots, Nanowires and Nanotubes, 2D films; Nano & mesopores – size dependent Variation in Magnetic, electronic transport, reactivity etc.

**UNIT IV** **9**

Forces between atoms and molecules, particles and grain boundaries, surfaces – strong intermolecular forces - Van der Waals and electrostatic forces between surfaces – similarities and differences between intermolecular and interparticle forces – covalent and coulomb interactions -thermodynamics of self-assembly; micelles, bilayers, vesicles – bio-nanomachines – biological membranes.

**UNIT-V** **9**

Influence of Nano structuring on Mechanical, optical, electronic, magnetic and chemical properties- grain size effects on strength of metals optical properties of quantum dots and quantum wires- electronic transport in quantum wires and carbon nano tubes

**TOTAL: 45 PERIODS**

**REFERENCES**

1. Nanotechnology: Basic Science and Emerging Technologies, Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse , Chapman & Hall/CRC, 1st Edition, 2002.

2. Understanding Nanotechnology, Scientific American, Warner Books, 2002.

3. Introduction to Nanotechnology by Charles P. Poole, Frank J. Owens, Wiley-Interscience, 2003.

4. Nanotechnology: A Gentle Introduction to the Next Big Idea, Mark A. Ratner, Daniel Ratner, Mark Ratner, Prentice Hall PTR, 1st edition, 2002.

5. Fundamental Properties of Nanostructured Materials, Fiorani. D., Sberveglieri, G, World Scientific, 1994.

6. NanoTechnology by Gregory Timp, Springer, Verlag, New York 1999.

7. Hand book of Nanoscience Engineering and Technology (HNEI), W.A. Godderd, D.W.Brenner SE Lysheki, CRC Press New York, 2003.

| NT1503 | SYNTHESIS OF NANOMATERIALS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**AIM**:

To study the basics of nanostructured materials and the various methods to prepare 0D, 1D and 2D nanomaterials.

**OBJECTIVE**:

The objective of this course is to understand the basic concepts of nanostructured materials, principle behind the various methods used to synthesize/prepare nanomaterials, understanding the various processes involved in the preparation of the nanomaterials.

**UNIT I NUCLEATION AND GROWTH 9**

Nano outline - introduction – various preparation techniques – basic concepts of nanostructure materials – nucleation: surface nucleation growth – thermodynamics of nucleation – coagulation of nano particles, aggregation

**UNIT II FILM DEPOSITION 9**

Fundamentals of film deposition – thermal evaporation – Spray Pyrolysis, Flame Pyrolysis - molecular beam epitaxy – pulsed laser deposition – sputter deposition – chemical vapour deposition – layer-by-layer growth and ultra thin films – chemical solution deposition.

**UNIT III SOL-GEL METHODS 9**

Sol-gel processing - fundamentals of sol-gel process – sol-gel synthesis methods for oxides – inorganics and nano composites - silica gel – zirconia and Yttrium gel – aluminosilicate gel – polymer nano composites.

**UNIT IV CNT GROWTH 9**

New forms of carbon – types of nanotubes – formation of CNT – methods and reactants - arcing in the presence of cobalt – laser methods –chemical vapour deposition methods – Catalytic route –plasma arcing electro deposition

**UNIT V SELF ASSEMBLY AND TEMPLATE SYNTHESIS 9**

Self-assembly, self-assembled monolayers (SAMs). Langmuir-Blodgett (LB) films, clusters, colloids, zeolites, emulsion polymerization, templated synthesis, crystallization - Electrochemical Approaches: anodic oxidation of alumina films, porous silicon, and pulsed electrochemical deposition.

**TOTAL: 45 PERIODS**

**REFERENCES**


1. Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, 2nd Edition, Rainer Waser, Wiley-VCH Verlag, Weiheim, 2005.
2. *Recent advances in the Liquid-phase Syntheses* of *Inorganic Nanoparticles*, *Brian L.Cushing*, *Vladimir L.Kolesnichenko*, *Charles J. O'Connor*, Chemical Reviews, American Chemical Society, Volume *104, Issue* 99, pp-*3893-3946, 2004*.
3. Nanocomposite Science and Technology, Pulickel M.Ajayan, Linda S.Schadler, Paul V.Braun, Wiley-VCH Verlag, Weiheim, 2003.
4. Amorphous and Nanocrystalline Materials: Preparation, Properties, and Applications, A. Inoue, K. Hashimoto, Springer, 1st Edition, 2001.
5. Optical Properties of Semiconductor Nanocrystals, S. V. Gaponenko , Cambridge University Press, 1st Edition, 1998.
6. Handbook of Nanoscience, Engineering, and Technology, William A. Goddard, Donald W. Brenner, Sergey E. Lyshevski, Gerald J. Iafrate, CRC, 1st Edition, 2002.
7. Low Dimensional Semiconductor Structures, Keith Barnham, Dimitri Vvedensky, Cambridge University Press, 1st Edition, 2001.

8. Self-Assembled Nanostructures (Nanostructure Science and Technology), Jin Zhang, Zhong-lin Wang, Jun Liu, Shaowei Chen, Gang-yu Liu, Springer, 1st Edition, 2002.
9. Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Guozhong Cao, Imperial College Press, 1st Edition, 2004.

| NT1504 | BIOMATERIALS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**AIM:**

To gain knowledge of the science of nanomaterials utilized in biological applications.

**OBJECTIVE:**

The objective of this course is to know the type of materials, their properties, biocompatibility, host reactions, chemical background, applications in medical field and certain tissue engineering aspects of biomaterials.

**UNIT I** **9**

Materials: Introduction – Bulk properties – Surface properties. Classes of Materials Used in medicine : Metals – Polymers – Hydrogels – Bioresorbable and Bioerodible Biomaterials – Ceramics, glasses – Natural materials – Composites – Thin films, Grafts, coatings – Fabrics – Biologically functional materials.

**UNIT II** **9**

Biology, Biochemistry and medicine: Proteins – Cells – Tissues. Host reactions to biomaterials: Inflammation, Wound Healing, and the Foreign Body Response - Immunology and the Complement System - Systemic Toxicity and Hypersensitivity – Blood Coagulation and Blood-Materials Interactions – Tumorigenesis and Biomaterials – Implant-associated Infection – Testing of Biomaterials.

**UNIT III** **9**

Natural Nanobiocomposites, Biomimetic Nanocomposites and Biologically Inspired Nanocomposites. Degradation of biomaterials in the biological environment: Chemical and biochemical degradation – Degradative effects – Mechanical breakdown – Pathologic calcification of biomaterials.

**UNIT IV** **9**

Applications of biomaterials in Medicine and dentistry: Cardio vascular – Non-thrombogenic treatment and strategies – Dental implants – Adhesives and sealants – Ophthalmologic applications – Orthopedic applications – Drug delivery systems – Sutures – Burn dressings – Bioelectrodes – Biomedical sensors and Biosensors.

**UNIT V** **9**

In-vivo cell & tissue engineering case studies: Artificial organs, Artificial skin, Artificial blood vessel, Artificial pancreas, Artificial liver, regeneration of bone, muscle and

nerve. Practical aspects of biomaterials – Implants and devices – New products and standards.

**TOTAL: 45 PERIODS**

**RERERENCES**


1. Biomaterials Science: An Introduction to Materials in Medicine, Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Academic Press, 1st edition, 1997.
2. Nanocomposite Science and Technology, Pulickel M.Ajayan, Linda S.Schadler, Paul V.Braun, Wiley-VCH Verlag, Weiheim, 2003.
3. Principles of Tissue Engineering, R.P.Lanza, R.Langer, J.Vacanti, Academic Press, 2nd Edition, 1997.


| NT1571 | SYNTHESIS AND PREPARATION OF NANOMATERIALS - LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 2 |

**AIM:**

To synthesize/ prepare the various nano-structured materials by various methods.

**OBJECTIVE:**

The objective of this course is to be familiar with the synthesis and preparation of 0D, 1D and 2D nano-structured materials, understand the chemical background involved in the chemical reactions.

**List of experiments**

1. Synthesis of silver nanoparticles
2. Synthesis of gold nanoparticles
3. Synthesis of iron oxide nanoparticles
4. Synthesis of cadmium selenide quantum dots
5. Synthesis of CuO and Cu2O crystalline nanowires
6. Preparation of bioactive glass ceramic nanoparticles
7. Preparation of nanocomposite containing iron and nickel–zinc ferrite
8. Preparation of polymer hydrogel
9. Preparation of PLGA nanoparticles
10. Preparation of PCL scaffold
11. Preparation of liposomes

**TOTAL: 45 PERIODS**

**RERERENCES**


**Exp No 1:**

Won-Sik Seo et al., "Synthesis of Silver Nanoparticles by Chemical Reduction Method", Korean Chem. Eng. Res., Vol. 42, No. 1, February, 2004, pp. 78-83.

**Exp No 2:**

Chien-Ying Tsa et.al., "An ultra sensitive dna detection by using gold nanoparticle multilayer in nano-gap electrodes", c.-y. tsai et al. / microelectronic engineering 78–79 (2005) 546–555.

Alfredo de la Escosura Muñiz et.al., "Electrocatalytical magnetobiosensing based on gold nanoparticles", ENS'07 Paris, france, 3-4 december 2007.

**Exp No 3:**

G. Ennas et.al., "Characterization of nanocrystalline G–Fe2O3 prepared by wet chemical method", J. Mater. Res., Vol. 14, No. 4, Apr 1999.

**Exp No 4:**

Jeaho Park et.al., "Synthesis of Cadmium Selenide Quantum Dots from a Non-Coordinating Solvent: Growth Kinetics and Particle Size Distribution", J. Phys. Chem. C 2008, 112, 17849–17854.

**Exp No 5:**

Wenzhong Wang et.al.,"Synthesis of CuO and $Cu_2O$ crystalline nanowires using $Cu(OH)_2$ nanowire templates", J. Mater. Res., Vol. 18, No. 12, Dec 2003.

**Exp No 6:**

Zhongkui Hong et.al., "Preparation of bioactive glass ceramic nanoparticles by combination of sol-gel and co-precipitation method", Journal of Non-Crystalline Solids 355 (2009) 368-372.

**Exp No 7:**

M.Pal et.al., "Preparation of nanocomposites containing iron and nickel-zinc ferrite", J. Mater. Res., Vol. 15, No. 15, Mar 2000.

**Exp No 8:**

Yihong Huang et.al., "pH-sensitive cationic guar gum/poly (acrylic acid) polyelectrolyte hydrogels: Swelling and in vitro drug release", Carbohydrate polymers, Vol. 69, (2007) 774–783.

**Exp No 9:**

Sanju Sourabhan et.al., "Method to enhance the encapsulation of biologically active molecules in PLGA Nanoparticles", Trends Biomaterials. Artificial Organs, Vol 22(3), pp 207-211 (2009).

**Exp No 10:**

Laszlo Olah et.al., "Properties of calcium carbonate-containing composite scaffolds", Acta of Bioengineering and Biomechanics Vol. 10, No. 1, 2008.

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**DEPARTMENT OF NANOTECHNOLOGY**

**M.TECH NANOTECHNOLOGY**

**CURRICULUM & SYLLABUS**

**SEMESTER – II**

| SL. NO | COURSE CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| **THEORY** | | | | | | |
| 1 | NT1505 | Advanced Characterization Techniques | 3 | 0 | 0 | 3 |
| 2 | NT1506 | Nanobiotechnology | 3 | 0 | 0 | 3 |
| 3 | NT1507 | Industrial Nanotechnology | 3 | 0 | 0 | 3 |
| 4 | NT1508 | Nanoelectronics and Sensors | 3 | 0 | 0 | 3 |
| 5 | NT1509 | Thermodynamics of Nanostructures | 3 | 0 | 0 | 3 |
| 6 | NT15E2 | Elective II: | 3 | 0 | 0 | 3 |
| **PRACTICAL** | | | | | | |
| 7 | NT1572 | Characterization of Nanomaterials – Laboratory | 0 | 1 | 2 | 2 |
| **TOTAL** | | | 18 | 1 | 2 | 20 |

| NT1505 | ADVANCED CHARACTERIZATION TECHNIQUES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**AIM:**

To be familiar with the various characterization techniques used to characterize the various properties of nanomaterials.

**OBJECTIVE:**

The objective of this course is to know the principle and working procedure of the various nano-characterization techniques that serve as important tools to describing the properties of nanomaterials and nanofeatures.

**UNIT I** **9**

Spectroscopy: UV-Vis spectroscopy – IR spectroscopy – Raman Spectroscopy – Brilloüin Spectroscopy – Mossbaüer Spectroscopy – NMR Spectroscopy – ESR Spectroscopy –Auger Electron Spectroscopy – Electron Energy Loss Spectroscopy

**UNIT II** **9**

Microscopy: Scanning Electron Microscopy – Transmission Electron Microscopy – Scanning tunneling microscopy – Scanning Probe Microscopy – Atomic force microscopy – MFM – EFM – Confocal microscopy

**UNIT III** **9**

X-Ray methods: X-Ray Diffraction, HRXRD – X-Ray Absorption Spectroscopy – Extended X-Ray Absorption of Fine Structures – X-Ray Photoelectron Spectroscopy – Evanescent wave spectroscopy – Energy Dispersive Analysis of X-rays

**UNIT IV** **9**

Thermal Analysis: Thermogravimetric Analysis – Differential Scanning Calorimetry – Thermo-Mechanical Analysis – Differential Thermal Analysis- Thermo optical analysis- Dielectric thermal analysis

**UNIT V** **9**

Mechanical Characterization – Mechanical Testing Machine (MTM) – F/D curve – Superplasticity – Nanoindentation – Nanotribology – Nanotribometer – Friction force microscope

**TOTAL: 45 PERIODS**

**REFERENCES**


1. Encyclopedia of Nanoscience & Nanotechnology, H. S. Nalwa (Ed.), American Scientific Publishers, California, 2004.
2. Instrumental Methods of Analysis, Willard. Merritt, Dean & Settle, CBS Publications, 6th Edition, 2000.
3. Nano: The Essentials, T.Pradeep. Tata McGraw Hill, New Delhi, 2007.
4. Introduction to Nanotechnology, Charles P Poole Jr, Frank J Ownes, John Wiley Sons, Inc., 2003.

**NT1506 NANOBIOTECHNOLOGY 3 0 0 3**

**PREREQUISITE:** Basic Biotechnology

**AIM:**

To be familiar with the concepts of biology that can help in designing new systems and devices using nanotechnology.

**OBJECTIVE:**

The objective of this course is to make out the human physiology, biological components of the cell, natural nanobiomaterials and the use of these materials as nanomachines and nanosystems.

**UNIT I BIOLOGY INSPIRED CONCEPTS 9**

Introduction to Biology inspired concepts - biological networks – biological Neurons – the function of neuronal cell – biological neuronal cells on silicon modeling of neuronal cells by VLSI circuits – bioelectronics – molecular Processor – DNA analyzer as biochip – molecular electronics.

**UNIT II NANOBIOMETRICS 9**

Introduction to Nano-biometrics - introduction – lipids as nano-bricks and mortar: self assembled nanolayers –proteins – 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 computer.

**UNIT III NATURAL NANO COMPOSITES 9**

Introduction- Natural nano composites - natural nano composite materials – biologically synthesized nano structures – biologically derived synthetic nano composites – protein based nanostructure formation – biologically inspired nano composites.

**UNIT IV BIOANALYTICAL TECHNIQUES 9**

Quantum dots – nanoparticle molecular labels analysis of biomolecular structure by AFM and molecular pulling-force spectroscopy– biofunctionalized nanoparticles for SERS and SPR. Quantum dots for in vivo molecular and cellular imaging- fluorescence based analysis of cellular protein lysate arrays using quantum dots

**UNIT V BIOMOLECULAR DEVICES 9**

Molecular motors – Myosin, Dyenin, ATP synthase- Helicase- enzyme conjugate- DNA conjugates- DNA-protein conjugates- molecular electronics- self organized nanomotors- cell mechanics.

**TOTAL: 45 PERIODS**

**REFERENCES**

1. Nanoelectronics and Nanosystems: From transistors to molecular devices. K.Goser, P. Glosekotter, J. Dienstuhl, Springer, 2004.

2. Nanotechnology: Basic Science and Emerging Technologies, Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse , Chapman & Hall/CRC, 1st Edition, 2002.

3. Nanobiotechnology**:** Concepts, Applications and Perspectives, Christof M.Niemeyer, Chad A.Mirkin, Wiley-VCH, Weinheim, 2004.

4. Bionanotechnology: Lessons from Nature, David S. Goodsell, Wiley-Liss, 2004.

5. NanoBiotechnology Protocols: Methods in Molecular Biology, Sandra J Rosenthal, David W. Wright, Humana Press, 1st Edition, 2005.

6. Protein Nanotechnology: Protocols, Instrumentation, and Applications: Methods in Molecular Biology, Tuan Vo-Dinh, Humana Press; 1st Edition, 2005.

7. Molecular machines and motors (structure and bonding), J.P Sauvage, ISBN:3-540-41382-2009

8. Quantum dots: application in Biology (methods in molecular biology), Charles Z Hotz, Marcer Bruchez, 2007, ISBN: 1-58829-562-1.

| NT1507 | INDUSTRIAL NANOTECHNOLOGY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**AIM:**

To know the concepts of industrial management in terms of need, design, criteria of selection, product development, management system and entrepreneurship.

**OBJECTIVE:**

The objective of this course is to develop the skills in managing a nanotechnology manufacturing company right from the need of a product to the commercial release of product.

**UNIT I** **9**

Concept generation – Product Architecture – Industrial Design Process – Management of Industrial Design Process and Assessing the equality of Industrial Design – Establishing the product specification.

**UNIT II** **9**

Criteria for selection of product – Product development process –design for Manufacture – Estimate the manufacturing cost – Reduce the support cost – Prototyping – Economics of Product development projects – Elements of Economic analysis-financial models- Sensitive analysis and influence of the quantitative factors.

**UNIT III** **9**

Technology Management – Scientific Management – Development of management Thought-Principles of Management – Functions of Management –planning – organization – Directing, Staffing and Controlling-Management by objective –SWOT analysis – Enterprise Resource planning and supply chain management.

**UNIT IV** **9**

Concept of Entrepreneurship – Entrepreneurship as a career – Personality Characteristic a successful Entrepreneurship – Knowledge and skill required for an Entrepreneur – Business environment – Entrepreneurship Development Training – Center and State government policies and Regulations – International Business.

**UNIT V** **9**

Pre-feasibility study-Ownership- budgeting – project profile preparation – Feasibility Report preparation – Evaluation Criteria – Market and channel selection – Product launching – Monitoring and evaluation of Business – Effective Management of Small business.

**TOTAL: 45 PERIODS**

**REFERENCES**


1. Product Design and Development, Karl T. Ulrich, Steven D. Eppinger, McGraw Hill Higher Education, 3rd Edition, 2003.
2. Effective Product Design and Development: How to Cut Lead Time and Increase Customer Satisfaction (Business One Irwin/Apics Library of Integrative Resource Management), Stephen R. Rosenthal, McGraw-Hill Professional Publishing, 1992.
3. Essentials of management, H.Koontz and H.Weihrich, McGraw Hill Publishing Company, Singapore international edition, 1980.
4. Essentials of management, J.J.Massie, Prentice Hall of India Pvt.Ltd., 1985.
5. Entrepreneurship, Hisrich, Tata McGraw Hill, 2001.


| NT1508 | NANOELECTRONICS AND SENSORS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**PREREQUISITE:** Basic microelectronic technologies and of electronic devices. Basic principles of organic chemistry and sensing

**AIM:**

To understand the principle and working of various nanoelectronic devices and sensors.

**OBJECTIVE:**

The objective of this course is to be familiar with the quantum mechanics for nanodevices. Using these new concepts, the student will be able to understand the principles of the design, the simulation and the fabrication of nanostructures for electronic devices and sensors.

**UNIT I FUNDAMENTALS OF NANOELECTRONICS** **9**

Electron energy bands, Semiconductor heterostructures, Lattice-matched and pseudomorphic heterostructures, Inorganic-organic heterostructures; Electron transport: Time and length scales of the electrons in solids, Statistics of the electrons in solids and

nanostructures, Density of states of electrons in nanostructures; Electrons in quantum wells, quantum wires and quantum dots

**UNIT II NANOELECTRONIC DEVICES 9**

Resonant-tunneling diodes, Field-effect transistors, Single-electron-transfer devices, Potential-effect transistors, Light-emitting diodes and lasers, Nano-electromechanical system devices

**UNIT III SENSOR CHARACTERISTICS 9**

Signal transduction; Physico-chemical and biological transducers; Sensor types and technologies, calibration and standard, selectivity, sensitivity, reproducibility, detection limits, response time

**UNIT IV PHYSICO-CHEMICAL SENSORS 9**

Criteria for the choice of materials for sensors, Temperature sensors, electromagnetic sensors, electric field sensors, magnetism sensors - pressure sensor, gas and liquid flow sensors, position sensors - Chemical sensors - Optical and radiation sensors, measurement of gas sensing property, Gas sensors based on semiconductor devices.

**UNIT V BIOSENSORS 9**

Catalytic biosensors: monoenzyme electrodes; bi-enzyme electrodes: enzyme sequence electrodes and enzyme competition electrodes; Affinity-based biosensors; Inhibition- based biosensors; Cell-based biosensors; Biochips and biosensor arrays; Problems and limitations

**TOTAL: 45 PERIODS**

**REFERENCES**


1. *Introduction to nanoelectronics: Science, nanotechnology, engineering, and applications*. Mitin, V. V., Kochelap, V. A., & Stroscio, M. A.. Cambridge: Cambridge University Press. (2008)
2. *Introduction to bioanalytical sensors*. Cunningham, A. J. New York: Wiley. (1998).
3. *The measurement, instrumentation, and sensors handbook*. Boca Raton, Fla: Webster, J. G. CRC Press published in cooperation with IEEE Press. (1999).
4. *Introduction to nanotechnology*. Poole, C. P., & Owens, F. J. Hoboken, NJ: J. Wiley. (2003).
5. *Nanoscience: Nanotechnologies and nanophysics*. Dupas, C., Houdy, P., Lahmani, M., & European Materials Research Society. Berlin: Springer. (2007)
6. *Sensors and transducers*. Patranabis, D. New Delhi: Prentice-Hall of India. (2004).
7. *Electronic instrumentation and measurement techniques*. Cooper, W. D.. Englewood Cliffs, N.J: Prentice-Hall. (1978)

| NT1509 | THERMODYNAMICS OF NANOSTRUCTURES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**AIM:**

To become proficient in the thermodynamic background of nanostructures and nanomaterials.

**OBJECTIVE:**

The objective of this course is to learn the laws of thermodynamics, concepts of thermodynamics, equilibrium, component systems, phases, difference between the thermodynamics of classical systems and small systems.

**UNIT I** **9**

Thermodynamics laws and relationship, concept of entropy and its relationship to heat – strategy for deriving thermodynamics relationships, general criterion for equilibrium – physical and chemical equilibria – Statistical thermodynamics: micro – and macro – states.

**UNIT II** **9**

Unary and multicomponent systems, Gibbs phase rule phase diagrams relevant to macro systems and for Nanoscale materials formation, theoretical and experimental aspects of first and second order phase transformations in nanoscale systems including correlation length truncation, nanoscale grain nucleation, film growth.

**UNIT III** **9**

Classification of thermodynamics systems, variables – state functions – process variables – extensive and intensive properties – formulation of general criterion for equilibrium – mathematical formulation of general criterion for equilibrium – chemical potential and Gibbs free energy – Gibbs adsorption equation – chemical potential surfaces; Clausius – Claypron equation.

**UNIT IV** **9**

Surfaces and curvature – geometry of surfaces –surface excess properties – equilibrium in systems with curved surfaces – surface tension – capillarity effects on phase diagrams – Gibbs – Wulff construction - adsorption at surfaces.

**UNIT V** **9**

Physical phenomena unique to small systems – classical thermodynamics – non – equilibrium statistical mechanics – distinction between standard thermodynamics and the thermodynamics of small systems – thermodynamically instability.

**TOTAL: 45 PERIODS**

**REFERENCES**

1. Thermodynamics of Small Systems, Terrell L. Hill, Courier Dover Publications, 2002.

2. Thermodynamics of Materials: Thermodynamics, Volume – 1, DV Ragone, John Wiley & Sons, 1994.
3. Thermodynamics: An Introduction to Thermostatistics, Herbert B. Callen, Wiley, 2nd Edition, 1985.
4. Quantum Thermodynamics: Emergence of Thermodynamically Behavior within Composite Quantum Systems , J.Gemmer, M.Michel, G.Mahler, Springer, Berlin, 2004.
5. Chemical Thermodynamics: Advanced Applications, J.B.Ott, J.Boerio Goates, Academic Press, San Diego, CA, 2000.

| | | L | T | P | C |
|---|---|---|---|---|---|
| **NT1572** | **CHARACTERIZATION OF NANOMATERIALS – LABORATORY** | **0** | **1** | **2** | **2** |

**AIM**:

To analyze the characteristics of nanomaterials using characterization techniques.

**OBJECTIVE**:

The objective of this course is to analyze the characteristic properties of nanomaterials like morphology, thermal, chemical, structural, optical, electrical, mechanical properties etc that forms the important criterion for their application.

**List of experiments**

1. Particle size – Microscopy, Centrifugal Sedimentation, Dynamic Light Scattering
2. Identification and Quantification of compounds – UV-Vis Spectroscopy
3. Identification of chemical bonds – FTIR
4. Thermal analysis – Differential Scanning Calorimeter
5. Crystallinity – X-Ray Diffraction
6. Surface area – Surface Area Analyzer
7. Nanofilm - Interferometry
8. Energy studies – Potentiostat
9. Contact angle – Goniometer
10. Fluorescence – Spectrofluorimeter
11. Porosity – Porosimeter
12. Mechanical property – Universal Testing Machine
13. Morphology – SEM/AFM/TEM
14. Conductivity – STM

**TOTAL: 45 PERIODS**

**NOORUL ISLAM CENTER FOR HIGHER EDUCATION**

**NOORUL ISLAM UNIVERSITY, KUMARACOIL**

**DEPARTMENT OF NANOTECHNOLOGY**

**M.TECH. NANOTECHNOLOGY**

**CURRICULUM & SYLLABUS**

**ELECTIVES**

| SL. NO | COURSE CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| **ELECTIVES FOR ODD SEMESTERS** | | | | | | |
| 1 | NT15A1 | Nanotoxicology | 3 | 0 | 0 | 3 |
| 2 | NT15A2 | MEMS and Bio-MEMS | 3 | 0 | 0 | 3 |
| 3 | NT15A3 | Nanotechnology and Environment | 3 | 0 | 0 | 3 |
| 4 | NT15A4 | Physics and Chemistry of Nanomaterials | 3 | 0 | 0 | 3 |
| 5 | NT15A5 | Nanomedicine and Healthcare | 3 | 0 | 0 | 3 |
| 6 | NT15A6 | Nanobiology | 3 | 0 | 0 | 3 |
| 7 | NT15A7 | Smart Nanosystems | 3 | 0 | 0 | 3 |
| 8 | NT15A8 | Biophysics | 3 | 0 | 0 | 3 |
| 9 | NT15A9 | Plasmonics and Photonics | 3 | 0 | 0 | 3 |
| **ELECTIVES FOR EVEN SEMESTERS** | | | | | | |
| 10 | NT15B1 | Lithography and Nanofabrication | 3 | 0 | 0 | 3 |
| 11 | NT15B2 | Drug Delivery Systems | 3 | 0 | 0 | 3 |
| 12 | NT15B3 | Nanomaterials Manufacturing Methods | 3 | 0 | 0 | 3 |
| 13 | NT15B4 | Green Energy | 3 | 0 | 0 | 3 |

| NT15A1 | NANOTOXICOLOGY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**PREREQUISITE:** Industrial safety

**AIM:**

To study the toxicity of the nanomaterials that are involved in the industrial processes

**OBJECTIVE:**

To study the possible toxicity of nanomaterials in the industrial handling operations and to know the safety measures to be followed

**UNIT I** **9**

Properties of nano powders – Powder classification – physical, chemical, thermal and other properties – Friction and Impact sensitivity – Toxicity – Explosivity – Metallic powders – Manual, mechanical, automatic handling methods –charges on powders – charge distribution – charging of powders

**UNIT II** **9**

Dust: Definition – type – concepts – exposure – dispersion – control – monitoring and measure–control of dust at the source – control approaches and strategies –occupational related diseases, lead–nickel, chromium, coal and manganese toxicity, their effects and prevention – local, systemic and chronic effects, temporary and cumulative effects, carcinogens entry into human systems

**UNIT III** **9**

Recognition of chemical hazards – dust, fumes, mist, vapour, fog, gases, types, concentration, Exposure Vs dose, TLV – Methods of Evaluation, process or operation description – Field Survey – Sampling methodology – Industrial Hygiene calculations – Comparison with OSHAS Standard

**UNIT IV** **9**

Volume reference – resistivity of solids–powders in bulk – surface resistance –static charge, conductivity –radio signals – minimum Ignition energy – particulate measurement – air sampler – dust monitor – Sampling instruments – types – Measurement procedures – Instruments Procedures – dust sample collection devices – personal sampling – Hazard identification and assessment in the process industries

**UNIT V** **9**

Safety measures in powder handling – loading and unloading – pneumatic transfer – sieving **–** grinding and mixing – control measures – PPE – earthing – elimination of incendiary discharge. Explosion prevention – handling of nano powders in the presence of flammable gases and vapour – safety measures in industries.

**TOTAL: 45 PERIODS**

**REFERENCES**


1. Electro Static Hazard in Powder Handling, Martin Glor, Research Studies Press Ltd., England, 1988.
2. Major hazard control–ILO Geneva, 1987.
3. Seminar on "Hazard recognition and prevention in the work place–airborne dust" Vol.1 & 2, SRMC, Chennai, Sep 4 & 5, 2000.
4. Hand book of Occupational Safety and Health, National Safety Council, Chicago, 1982.


**NT15A2 MEMS AND BIOMEMS 3 0 0 3**

**Prerequisite:** Electromechanics

**Aim:**

To study the micro-scale electrical and mechanical systems and devices.

**Objective:**

To study the fabrication process of MEMS and the scientific and technological applications of MEMS and BIOMEMS.

**Unit I Fabrication 9**

Introduction to Fabrication – design and application scaling issues – scaling fluidic biological systems – influence of scaling on material properties.

**Unit II Properties of MEMS 9**

Physics of MEMS-scaling laws heat transfer - mechanics and electro statistics – batch Fabrication – Types of circuits- circuit integration- properties influencing nanofabrication

**Unit III Nanomaterials for MEMS 9**

Nano materials for MEMS and pro-MEMS – silicon - metals and polymers- complex nanomaterials for layer fabrication- smart probes and materials- Quantum dot based devices

**Unit IV Microfluidics 9**

Introduction – Laws of microfluidics- Principles and properties of microfluidics- BioMEMS for genomics and post genomics-microfluids for bio-diagnosis lead discovery platforms-construction of microchannels

**Unit V Lab on a chip 9**

Introduction to Lab on a chip- Micro array chip- Micro pumps- Sensors – flow sensors – chemical sensors– Nano HPLC system, Nano PCR and Nano Electrophoresis- flow cytometers- nanobiosensor chips- smart sensors

**REFERENCES**

1. M. J. Madou, Fundamentals of Microfabrication, CRC Press, 1997.
2. Héctor J. De Los Santos, Introduction to Microelectromechanical (MEM) Microwave Systems, Artech House, 1999.
3. Gregory Kovacs, Micromachined Transducers Sourcebook, McGraw-Hill, 1998.
4. Sergey Edward Lyshevski, Nano and Microelectromechanical Systems, CRC Press, 2000.
5. Wanjun Wang, Steven A.Soper, Bio-MEMS – Technologies and Applications, CRC Press, 2006.
6. Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, McGraw-Hill, 2001.
7. R. Edwin Oosterbroek, A. J. van den Berg, Lab-on-a-Chip: Miniaturized Systems for (Bio)Chemical Analysis and Synthesis. First Edition, Elsevier B.V., 2003.

| NT15A3 | NANOTECHNOLOGY AND ENVIRONMENT | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**PREREQUISITE:** Environmental engineering, Energy engineering

**AIM:**

To be familiar with the energy obtained using nanoparticle systems, the conventional energy sources, and the effect of all these energy sources on the environment.

**OBJECTIVE:**

To study the sources of energy on earth, effects of energy sources on the environment, application of nanoparticles in energy engineering and certain important concepts of green chemistry.

**UNIT I** **9**

Origin of the earth-Earth's temperature and atmosphere-Sun as the source of energy - Biological processes-photosynthesis-food chains-Energy sources-classification of energy sources, quality and concentration of energy sources-Overview of world energy scenario; Fossil fuel reserves - estimates, duration, overview of India's energy scenario, energy and development linkage.

**UNIT II** **9**

Environmental effects of energy extraction, conversion and use-Sources of pollution; primary and secondary pollutants; Consequence of pollution growth; Air, water, soil, thermal, noise pollution- cause and effect; Causes of global, regional and local climate change; Pollution control methods; Environmental laws on pollution control.

**UNIT III** **9**

Global warming; Green House Gas emissions, impacts, mitigation; Sustainability; Externalities; Future Energy Systems; Clean energy technologies; United Nations Framework Convention on Climate Change (UNFCC)-Sustainable development - Kyoto Protocol; Conference of Parties (COP)-Clean Development Mechanism (CDM); Prototype Carbon Fund (PCF).

**UNIT IV** **9**

Principles of green chemistry- green synthesis in a chemical laboratory-solvent free process solvent free techniques-microwave synthesis: Introduction – characteristics of microwave heating – interaction of microwave radiation with the materials-difference between microwave heating and conventional heating-Sonochemical synthesis.

**UNIT V** **9**

Zerovalent iron nanoparticles- titanium dioxide-silver nanoparticles-nanomembrane process nanosorbants- mesoporous silica-ground water remedian - air purifier - Nano photocatalysis - nanocoating- corrosion prevention- nanosolar thermal absorber-Nano-based environmental treatment.

**TOTAL: 45 PERIODS**

**REFERENCES**

1. Energy and Environment: A Primer for Scientists and Engineers, Thorndike, Edward H, Addison–Wesley Publication Company, 1976.
2. Environmental Nanotechnology, Mark Wiesner, Jean–Yves Bottero, McGraw–Hill, 2007.
3. Green chemistry (Microwave synthesis), K.R.Desai, Himalaya Publishing House, Mumbai, 2005.
4. Energy and the Challenge of Sustainability, World Energy assessment, UNDP, New York, 2000.
5. Renewable Energy and Environment – A Policy Analysis for India, Ravindranath N.H., Usha Rao K., Natarajan B., Monga P., Tata McGraw Hill, 2000.
6. Energy and the Environment, Fowler, J.M., 2nd Edition, McGraw Hill, New York, 1984.

| NT15A4 | PHYSICS AND CHEMISTRY OF NANOMATERIALS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**PREREQUISITE:** Science of Nanomaterials

**AIM**:

To study the physical phenomena and chemical kinetics involved in the nanostructured materials.

**OBJECTIVE**:

To study the surface physics and chemistry of nanostructured materials,chemical properties inherent to the nanostructured materials, electronic structure of nanomaterials, growth of CNTs.

**UNIT I** **9**

Melting point and phase transition processes-quantum-size-effect (QSE)-Size-induced metal insulator- transition (SIMIT)- Nano-scale magnets, transparent magnetic materials, and ultrahigh-density magnetic recording materials-chemical physics of atomic and molecular clusters.

**UNIT II** **9**

Surface energy – chemical potential as a function of surface curvature-Electrostatic stabilization-surface charge density-electric potential at the proximity of solid surface - Vander Waals attraction potential.

**UNIT III** **9**

Photochemistry- Photoconductivity- Electrochemistry of Nanomaterials-Diffusion in Nanomaterials-Nanoscale-Heat Transfer-Catalysis by Gold Nanoparticles - Transport in Semiconductor Nanostructures - Nanodeposition of Soft Materials- Nanocatalysis

**UNIT IV** **9**

Electronic Structure of Nanoparticles - Kinetics in Nanostructured Materials- Zero dimensional, one-dimensional and two dimensional nanostructures- clusters of metals and semiconductors, nanowires, nanorods and nanocomposites - artificial atomic clusters-size dependent properties-size dependent absorption spectra-phonons in nanostructures

**UNIT V** **9**

Single walled carbon nanotube - inorganic nanotube - Nanoparticles through homogeneous nucleation-Growth controlled by diffusion-growth controlled by surface process-influences of reduction reagents-solid state phase segregation-kinetically confined synthesis of nanoparticles-template based synthesis-nano structured polymers-conducting polymers nanocages - pillared clays- micelles.

**TOTAL: 45 PERIODS**

**REFERENCES**

1. Physics and Chemistry of Nanostructured Materials, Yang.S, Shen. P. Taylor & Francis, 2000.

2. Nanomaterials: Synthesis, Properties and Applications, Edelstein. A. S., Cammarata, R.C, Institute of Physics Pub., 1998.

3. Surface Science: Foundations of Catalysis and Nanoscience, Kolasinski, K.W., Wiley, 2002.

4. The Physics and Chemistry of Materials, Joel I.Gersten, Wiley, 2001.
5. Nanochemistry, A chemical approach to Nanomaterials, Ozin G.A., Arsenault A.C., Royal Society of Chemistry, 2005.

| NT15A5 | NANOMEDICINE AND HEALTHCARE | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**PREREQUISITE:** Basic Biotechnology

**AIM:**

To cover the concepts of nanomedicine and their potential applications in the healthcare industry

**OBJECTIVE:**

The objective of this course is to know the pharmaceutical revolutions due to nanotechnology, new generation devices, implants made of nanomaterials and the diagnostic techniques that exploit the nanoscale components

**UNIT I** **9**

History of Nanomedicine – Taxonomy – BioPharmaceuticals – Implantable Materials – Implantable Devices – Tissue Engineering scaffold – Diagnostic Tools – Imaging – Respirocytes – DNA motor

**UNIT II** **9**

Electrochemical Nanoelectrodes – Nanoelectrode properties – applications in biomedicine – *in vivo* imaging for the detection of tumors, plaque, genetic defects – Nanobot medical devices

**UNIT III** **9**

Immunoassay – Bio-barcode Assay – use of magnets, gold, DNA and antibodies – Superparamagnetism – nanomagnetic particles & magnetic separation – Nanomagnetics for Biomedical Applications – biosampling in lab-on-a-chip using nanomagnetic particles

**UNIT IV** **9**

New generations of prosthetic and medical implants – biocompatibility and reduced rejection ratio – Nanostructured Surface Modifications for Biomedical Implants – Orthopedic & dental implants - nanostructured diamond coatings – nanostructured hydroxyapatite coatings – nanostructured metalloceramic coatings

**UNIT V** **9**

Animation of the PCR – DNA profiling – Cantilever Sensors – Electrochemical Impedance Spectroscopy (EIS) – Nanoparticles for Live-Cell Dynamics - applications of

live-cell dynamics – intracellular cell motility, cell motility, single membrane transporters, membrane permeability, ligand-receptor interactions, chemical analysis

**TOTAL: 45 PERIODS**

**REFERENCES**


1. Encyclopedia of Nanoscience & Nanotechnology, H. S. Nalwa (Ed.), American Scientific Publishers, California, 2004.
2. The Immunoassay Handbook, David Wild, 3rd Edition, Amsterdam: Elsevier, 2005.
3. Electrochemical Methods: Fundamentals and Applications, Allen UJ Bard, Larry.R Faulkner, Wiley, New York, Chichester, 20th Edition, 2001.
4. Tissue Engineering, John P. Fisher, Antonios G. Mikos, Joseph D. Bronzino, Crc Press, 2007.


| NT15A6 | NANOBIOLOGY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**PREREQUISITE:** Nanomaterials

**AIM:**

To know about the nano sized components of the cellular system and their functions

**OBJECTIVE:**

To understand the basic cell and molecular biology and the biotechnology experiments that will bridge the gap between engineering and biology

**UNIT I** **9**

Cell biology: Structure and organization of prokaryotic and eukaryotic cell – cellular organelles – tissues and organs – The cell cycle: Mitosis and Meiosis – transport processes across cell membrane – active transport – passive transport – facilitated transport – signal transduction

**UNIT II** **9**

Molecular biology: Introduction to Gene – DNA structure – RNA – protein – central dogma – DNA replication – transcription – translation – mutation

**UNIT III** **9**

rDNA technology – DNA chip technology – microarrays – Genetic engineering – Gene cloning – cDNA libraries – Chromosome walking – Polymerised Chain Reaction –

Gene therapy – Gene delivery – gene sequencing methods – Nanopore DNA sequencing – DNA Tweezers

**UNIT IV** **9**

Immunology – Types of Immunity – Components of Immune system – Antigen – antibody structure and its types – humoral immunity – Cell mediated immunity – Antigen Presenting cells – MHC & its types antigen presentation – complement system – Hypersensitivity – graft transplantation – graft rejection.

**UNIT V** **9**

Biogenic Nanoparticles – Biomineralization – Magnetosomes – S–layer proteins – bio–nano molecular motors – Nanostructures in marine organisms – DNA based Nanostructures. Protein based Nanostructures – cyclodextrin based nanostructures – surfactant assisted Gene delivery

**TOTAL: 45 PERIODS**

**REFERENCES**


1. Cell & Molecular Biology – Concepts & Experiments, 3/e, Gerald Karp, John Wiley & Sons, 2007
2. Molecular Cell Biology, J. Darnell, H. Lodish & D. Baltimore Freeman, 1990.
3. Genes VII, Benjamin Lewin, Oxford University Press, Oxford, 1994.
4. Immunology, Kuby J, WH Freeman & Co., 2000
5. Environmental Biotechnology, Foster C.F. John ware, D.A. Ellis, Honwood Ltd. 1987
6. Nano bio–technology: Concepts, Applications and Perspectives, Christofer M. Niemeyer, Wiley, 2004
7. Nanotechnology: Basic Science and Emerging Technologies, Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Chapman & Hall/CRC, 1st Edition, 2002.
8. Nano Particles, Gunter Schmid (Ed), John wiley and sons limited, 2004
9. Nano Biotechnology, K.K.Jain, Horizions Biosciences, 2006


| NT15A7 | SMART NANOSYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**PREREQUISITE :** Basics of Nanotechnology

**AIM:**

To study the smartness of nanomaterials when they respond t a specific type of trigger

**OBJECTIVE:**

To study the various external triggers to which the different nanosystems respond and bring about novel applications for them

**UNIT I** **9**

Smart nanoparticles: definition – types of external triggers – Smart polymer nano and microgels for drug delivery: Preparation of Nanogels by Microemulsion Polymerization – Physicochemical Crosslinking – Stimuli Responsive Nanogels – pH Responsive Nanogels – Thermoresponsive Nanogels – Cyclodextrin-Responsive Nanogels – Photoresponsive Nanogels – Self Oscillating Nanogels – Nanogel Applications in Drug Delivery

**UNIT II** **9**

Thermoresponsive Nanosystems: Thermoresponsive Polymer Assemblies – Polymeric Micelles – Drug Trafficking in Drug Resistant Cells – Drug Cytotoxicity in Sensitive and Resistant Cells – Thermoresponsive Liposomes - Membrane Transition and Permeability -Phospholipid Selection - Fate of Lysolipid during Gel-Liquid Transition - Permeability during Gel-Liquid Transition - Liquid Phase Permeability - Thermoresponsive Drug Release - In Vivo Evaluations

**UNIT III** **9**

pH Responsive Nanosystems: Biophysical Properties of pH Sensitive Liposomes - Drug Loading by pH Gradient - Liposome-Cell Interactions and Mechanism of Intracellular Drug Delivery - pH Sensitive Liposomes without DOPE - In Vivo Evaluation of pH Sensitive Liposomes - pH Sensitive Liposomes for Nucleic Acid Delivery

**UNIT IV** **9**

Ultrasound responsive nanosystems: Ultrasound in Drug Delivery – Ultrasound Energy Deposition Pattern in the Body – Cavitation – Optison Microbubbles – Interactions with Cells – In Vivo Evaluation of Ultrasound Activated Micellar Drug Delivery – Sonication Variables – Mechanism of Ultrasound Targeting of Polymer Micelles - Optimal Time window

**UNIT V** **9**

Magnetoresponsive systems: Magnetic Particles for Hyperthermic Therapy – Embolotherapy – Delivery of Chemotherapeutic Drugs – Radionuclide Therapy (Brachytherapy) – Gene Delivery - Virus-like nanoparticles for gene therapy: Polycations for Gene Delivery In Vitro; DNA Complexation with Novel Surfactants - Artificial Viruses with Surface Modified DNA Particles; Targeting PEG-Folate Modified DNA Nanoparticles

**TOTAL: 45 PERIODS**

**REFERENCES**

1. Nanoscale Science and Technology, Kelsall, R, Hamley, I.W., Geoghegan, M. Wiley, 2005.
2. VLSI Technology, Chang.C.Y., S.M.Sze, McGraw–Hill Companies Inc., Singapore, 1996.
3. Silicon processing for the VLSI era, Wolf. S., Vol–1 to 4, Lattice Press.2005.
4. VLSI fabrication principles: Silicon and Gallium Arsenide, Ghandhi, S.K., 2nd Edition, Wiley–Interscience, 1994.

| NT15A8 | BIOPHYSICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**PREREQUISITE:** Environmental engineering, Energy engineering

**AIM:**

To study the physical aspects of the biological system

**OBJECTIVE:**

To be well informed about the physical phenomenon and properties that occurs in the biological system and the various methods adopted to characterize these properties

**UNIT I** **9**

Chemical binding – Pauli Exclusion Principle – Ionization energy – electron affinity – electronegativity – forces and bonds – rates of reactions – transport processes – diffusion – viscosity – thermal conduction

**UNIT II** **9**

Biomolecules – organization of molecules – physics of biomolecules – structural organization of proteins and nucleic acid – genetic code – transfer of genetic information – physics of biological membranes – types of transport thru membranes – Extracellular matrix – proteins – sequencing – carbohydrates – lipids – nucleic acids

**UNIT III** **9**

Thermodynamics and biological systems – bioenergetics – principles of kinetics of molecules – diffusion – osmosis – filtration – dialysis – absorption – hydrotropy – precipitation –viscosity – colloids – Gibb's Donnan equilibrium

**UNIT IV** **9**

Studies on biomolecules: pH meter – buffers in biological systems – centrifugation – centrifuges – chromatography(Qualitative) – electrophoresis – electron

microscopy(qualitative) – X-Ray crystallography – Spectroscopy(Qualitative) – Optical Rotatory Dispersion – Circular Dichroism – Mass spectrometry – LASER techniques

**UNIT V** **9**

Biomechanics – striated muscles – mechanical properties of muscles – biomechanics of cardiovascular system – Neurobiophysics – nervous system – membrane potentials – sensory mechanism-eye – hearing – signal transduction – molecular modelling - generating the model – building nucleic acid structures and protein structures – optimising the model – Origin and evolution of life

**TOTAL: 45 PERIODS**

**REFERENCES**


1. Biophysics – An Introduction, Rodney Cotterill, John Wiley & Sons Ltd. 2002.
2. Biophysics – Principles and Techniques, M.A. Subramanian, MJP Publishers, 2008.
3. Elementary Biophysics, P.K. Srivastava, Narosa Publishing House, 2005.
4. Biophysics, G.R. Chatwal, Himalaya Publishing House, 2005.
5. Biophysics, Vasantha Pattabhi, N. Gautham, Narosa Publishing House, 2003


| NT15A9 | PLASMONICS AND PHOTONICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**PREREQUISITE:** Science of nanomaterials

**AIM:**

To study the concepts of plamonics and photonics

**OBJECTIVE:**

To obtain knowledge on the photonics and electronics at the nanoscale and also the interactions that occur when light interacts with cells and tissues

**UNIT I** **9**

Elements of Plasmonics: Introduction – merging photonics and electronics at nanoscale dimensions – single photon transistor using surface Plasmon – nanowire surface plasmons – single emitter as saturable mirror – photon correlation – optical modulation by plasmonic excitation of quantum dots – Channel plasmon-polariton guiding by subwavelength metal grooves

**UNIT II** **9**

Physics of Linear Photonic Crystals: Maxwell's Equations – Bloch's Theorem – Photonic Band Gap and Localized Defect States – Transmission Spectra – Nonlinear Optics in Linear Photonic Crystals– Guided Modes in Photonic Crystals Slab

**UNIT III** **9**

Technology of Photonic Crystals: Choices of Materials: Semiconductors, Amorphous, and Polymers – Fabrications of Photonic Crystals Structures (1-D, 2-D, 3-D) – Applications of Photonic Crystals Devices: 1-D Photonic Crystals – Couplers – Waveguides – High-Q Cavities – 2-D Photonic Crystals – Photonic Crystal Fibers – 4 Tunable Photonic Crystal Filters

**UNIT IV** **9**

Physics of Nonlinear Photonic Crystals: 1-D Quasi Phase Matching – Nonlinear Photonic Crystal Analysis – Applications of Nonlinear Photonic Crystals Devices – Materials: LiNbO3, Chalcogenide Glasses – Wavelength Converters

**UNIT V** **9**

Biophotonics: Interaction of light with cells – tissues – nonlinear optical processes with intense laser beams – photo-induced effects in biological systems – generation of optical forces – optical trapping and manipulation of single molecules and cells in optical confinement – laser trapping and dissection for biological systems

**TOTAL: 45 PERIODS**

**REFERENCES**


1. The Handbook of Photonics, Mool Chand Gupta, John Ballato
2. Nanotechnology for Microelectronics and Optoelectronics, J. M. Martinez-Duart, Raúl J. Martín-Palma, Fernando Agullo-Rueda
3. Nanoplasmonics, From fundamentals to Applications Vol 1 & 2, S. Kawata & H. Masuhara
4. Optical Properties of Photonic Crystals, K. Sakoda
5. Applied Photonics, Chai Yeh
6. H.Masuhara, S.Kawata and F.Tokunaga, Nano Biophotonics, Elsevier Science, 2007
7. P.N.Prasad Introduction to Biophotonics, John Wiley & Sons, 2003.


**NT15B1 LITHOGRAPHY AND NANOFABRICATION 3 0 0 3**

**PREREQUISITE:** Nanotechnology

**AIM:**

To study the various lithographic techniques involved in the fabrication of nanomaterials.

**OBJECTIVE:**

To understand the uses of clean room for the nanofabrication and to study the different lithographic methods used to fabricate nanomaterials, the various phenomena involved in these process.

**UNIT I** **9**

Necessity for a clean room- different types of clean rooms-construction and maintenance of a clean room- Lithography -Optical lithography- Optical projection lithography- Multistage Scanners- Resolution- Photomask:- Binary Mask- Phase Shift Mask (PSM)- Attenuated Phase Shift Masks (AttPSMs)- Alternating Phase Shift Masks (AltPSMs)- Off Axis Illumination- Optical immersion lithography- Optical interferometric lithography- Holographic Lithography

**UNIT II** **9**

MOPL (Maskless Optical Projection Lithography) - ZPAL (Zone Plate Array Lithography) - EUVL (Extreme Ultraviolet Lithography). Electron beams for lithography- Micronic laser systems

**UNIT III** **9**

SEBL Scanning electron-beam lithography- Maskless (ML2) EBL: parallel direct-write e-beam systems-E-beam projection Lithography (EPL) - SCALPEL Scattering with Angular Limitation Projection E-beam lithography- PREVAIL Projection reduction exposure with variable axis immersion lenses.

**UNIT IV** **9**

Ion beam Lithography- Focused Ion beam Lithography (FIB) - Ion Projection Lithography (IPL) - Projection Focused Ion Multibeam (PROFIB) - MIBL Masked Ion Beam Lithography- MIBS Masked Ion Beam Direct Structuring- atom lithography

**UNIT V** **9**

Nanoimprint lithography (NIL) - NIL- hot embossing- UV-NIL- Soft Lithography- Molding/Replica molding: Printing with soft stamps- Edge lithography -Dip-Pen Lithography-set up and working principle. Etching techniques- Reactive Ion etching- RIE reactive ion etching- MERIE Magnetically enhanced RIE- IBE Ion beam etching- Other etching techniques.

**TOTAL: 45 PERIODS**

**REFERENCES**

1. Electron projection technology approach for next generation lithography, D. S. Dhaliwal et al., IBM Journal Res & Dev, Volume – 45, Issue – 615, 2001.
2. Lithographic pattern formation via metastable state rare gas atomic beams, Nanotechnology, M. Baker et al., Volume - 15, 1356, 2004.
3. Fabrication of polymer photonic crystals using Nanoimprint lithography, Nanotechnology, H. Schiff et al., Volume - 16, 261, 2005.
4. Dip-Pen Nanolithography, R.D. Piner, Science Volume - 283, 66, 1999.

| NT15B2 | DRUG DELIVERY SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**AIM:**

To study the concept behind the various types of drug delivery systems

**OBJECTIVE:**

The objective of the course is to understand the phenomenon taking place inside the body when a drug is administered via the various drug delivery systems

**UNIT I** **9**

Principles of drug delivery systems – Pharmacokinetics & Pharmacodynamics(qualitative) - ADME hypothesis – routes of administration - advantages and limitations – modes of drug delivery – controlled drug delivery – microneedles, micropumps and valves – sustained release system – targeted drug delivery – barriers for drug targeting – passive and active targeting – antibody–based targeting

**UNIT II** **9**

Diffusion & drug dispersion – Fick's first & second laws – Cases: With no solute elimination or generation, With solute binding & elimination – Diffusion in biological systems – Measurement of diffusion coefficients – Diffusion in water, polymer solutions & gels, in extracellular space, with binding in tissues, within cells

**UNIT III** **9**

Drug permeation through biological barriers – Mobility of lipids & proteins in membrane –Permeation through lipid membranes, porous membranes, through cell layers – Enhanced permeation by membrane proteins – Drug transport through fluid motion – Blood movement in the circulatory system – Interstitial fluid movement – Fluid movement in lymphatic circulation, brain

**UNIT IV** **9**

Pharmacokinetics of drug distribution – Compartment models – Physiological models –Mixing in tissues & organs – Drug delivery – Drug modification – Agent solubility – stability – enhancement of stability – Regulating agent permeability

**UNIT V** **9**

Controlled drug–delivery systems – Reservoir & transdermal delivery systems – Matrix delivery systems – Hydrogel delivery systems – Degradable delivery systems – Particulate delivery systems – Responsive delivery systems

**TOTAL: 45 PERIODS**

**REFERENCES**


1. 1. Drug Delivery: Engineering Principles for Drug Therapy, W. M. Saltzman, Oxford University Press, 2001.
2. Drug Delivery and Targeting, A.M.Hillery, CRC Press, 2002
3. Nanoparticulate Drug Delivery Systems Deepak Thassu , Michel Deleers (Editor), Yashwant Pathak (Editor) ISBN–10: 0849390737 ISBN–13: 9780849390739

| NT15B3 | NANOMATERIALS MANUFACTURING METHODS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**PREREQUISITE:** Synthesis of Nanomaterials

**AIM:**

To understand thy formation of nanomaterials by the two approaches of nanotechnology

**OBJECTIVE:**

To be sound on the top-down and bottom-up approaches of nanotechnology for synthesizing nanomaterials

**UNIT I** **9**

Sol-gel synthesis – different types of coatings – Spin coating – Self assembly – Self Assembled Monolayers(SAMs) – Periodic starting points for self assembly – Directed self assembly – Template self assembly –Vapor liquid solid growth – Langmuir-Blodgett films – DNA self assembly

**UNIT II** **9**

Physical vapor deposition – Sputter technologies – Diode sputtering – Magnetron sputtering – Ion beam (sputter) deposition – ion implantation and ion assisted deposition – Cathodic arc deposition – Pulsed laser deposition

**UNIT III** **9**

CVD Chemical vapor deposition – Atmospheric pressure CVD (APCVD) – Low pressure CVD (LPCVD) – Plasma enhanced chemical vapor deposition (PECVD) – The HiPCO method – Photo-enhanced chemical vapor deposition (PHCVD) – LCVD Laser-Induced CVD

**UNIT IV** **9**

Epitaxy – Different kinds of epitaxy – Influence of substrate, substrate orientation and mismatch – Metal Organic Chemical Vapor Deposition (MOCVD) – Combustion Chemical Vapor Deposition (CCVD) – Atomic Layer Deposition (ALD) – Liquid phase epitaxy (LPE) – Molecular Beam Epitaxy (MBE)

**UNIT V** **9**

Micro fabrication and Moore's law – Importance of lithographic techniques – Different types of lithographic techniques(Qualitative) – Micromilling/microdrilling/microgrinding processes – Procedure for selecting proper machining parameters with given specifications – EDM micro machining – Laser micro/nanomachining – Models to simulate micro/nanomachining processes using molecular dynamics techniques –Wet chemical etching – Dry etching – Thin film and sacrificial processes

**TOTAL: 45 PERIODS**

**REFERENCES**


1. Nanostructures & Nanomaterials: Synthesis, Properties &Applications, Guozhong Cao, Imperial College Press, 2004.
2. Nanoscale Assembly: Chemical Techniques (Nanostructure Science and Technology), Huck.W.T.S., Springer, 2005.
3. Handbook of Nanoscience Engineering and Technology, Gdoutos E.E. and I.M.Danies, eds., Kluwer publishers, 2002.
4. Micro fabrication and Nanomanufacturing, Jackson, M.J., CRC Press, 2005.
5. Fundamentals of Microfabrication, Madou M., CRC Press, 1997.
6. Nanotechnology, Gregory Timp, AIP press, Springer-Verlag, New York, 1999


| NT15B4 | GREEN ENERGY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**PREREQUISITE:** Energy Engineering

**AIM:**

To study the ways and means of sustaining a green environment using the concepts of nanotechnology

**OBJECTIVE:**

To know the measures to set a green environment for energy resources and to harness them

**UNIT I** **9**

Introduction: Nanotechnology for sustainable energy – Materials for light emitting diodes – batteries –Advanced turbines – catalytic reactors – capacitors – fuel cells

**UNIT II** **9**

Renewable Energy Technology: Energy challenges – renewable energy technologies – nanotechnology enabled renewable energy technologies – Energy transport, conversion and storage – Nano, micro and meso scale phenomena and devices

**UNIT III** **9**

Fuel Cell Technology: Micro-fuel cell technologies – integration and performance for micro-fuel cell systems – thin film and microfabrication methods – power sources – nanocatalysis for fuel cell applications – Bio-fuel cell

**UNIT IV** **9**

Microfluidic Systems: NEMS and novel microfluidic devices – nano-engines – driving mechanisms – power generation – microchannel battery – micro heat engine (MHE) fabrication – thermocapillary forces – Thermocapillary pumping (TCP) – piezoelectric membrane

**UNIT V** **9**

Hydrogen Storage Methods: size effects – hydrogen storage capacity – hydrogen reaction kinetics – carbon-free cycle – gravimetric and volumetric storage capacities –

hydriding/dehydriding kinetics – distinctive chemical and physical properties – multiple catalytic effects – degradation of the sorption properties – hydride storage materials for automotive applications

**TOTAL: 45 PERIODS**

**REFERENCES**


1. Renewable Energy Resources, Twidell. J.and Weir,T., E & F N Spon Ltd, London, 1986.
2. Fuel Storage on Board Hydrogen Storage in Carbon Nanostructures, Fuel Cell technology Handbook, Shatwell, R.A, CRC Press, 2003.
3. Handbook of fuel cells: Fuel cell technology and applications, Vielstich,H., Wiley, CRC Press, 2003.