M. Tech. (Full Time) NANOTECHNOLOGY
CURRICULUM & SYLLABUS
2018 – 2019

FACULTY OF ENGINEERING AND TECHNOLOGY
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY
SRM NAGAR, KATTANKULATHUR – 603 203

COURSE CODE	COURSE NAME	L	T	P	C
SEMESTER I					
NT2001	FUNDAMENTALS OF NANOSCIENCE AND NANO TECHNOLOGY	4	0	0	4
NT2002	NANOSCALE MATERIALS: SYNTHESIS AND CHARACTERIZATION	3	0	2	4
NT2003	METAMATERIALS AND NANOPHOTONICS	4	0	0	4
MA2018	APPLIED MATHEMATICS TO NANOTECHNOLOGISTS	3	0	0	3
CAC2001	CAREER ADVANCEMENT COURSE FOR ENGINEERS - I	1	0	1	1
	PROGRAM ELECTIVE I	3	0	0	3
	PROGRAM ELECTIVE II	3	0	0	3
Total		**21**	**0**	**3**	**22**
Total Contact Hours		24			
SEMESTER II					
NT2004	NANOSCALE TECHNOLOGY IN BIOLOGICAL SYSTEMS	3	0	2	4
NT2005	MOLECULAR AND NANOELECTRONICS	3	0	2	4
NT2006	INDUSTRIAL TRENDS AND APPLICATIONS OF NANOTECHNOLOGY	4	0	0	4
CAC2002	CAREER ADVANCEMENT COURSE FOR ENGINEERS - II	1	0	1	1
	PROGRAM ELECTIVE III	3	0	0	3
	PROGRAM ELECTIVE IV	3	0	0	3
	INTERDISCIPLINARY ELECTIVE	3	0	0	3
Total		**20**	**0**	**5**	**22**
Total Contact Hours		**25**			
SEMESTER III					
	PROGRAM ELECTIVE V	3	0	0	3
	PROGRAM ELECTIVE VI	3	0	0	3
NT2047	SEMINAR	0	0	1	1
NT2048	INDUSTRIAL TRAINING	0	0	1	1

NT2049	PROJECT WORK PHASE I	0	0	12	6
CAC2003	CAREER ADVANCEMENT COURSE FOR ENGINEERS - III	1	0	1	1
Total		**7**	**0**	**15**	**15**
Total Contact Hours		**22**			
SEMESTER IV					
NT2050	PROJECT WORK PHASE II	0	0	32	16
Total		**0**	**0**	**32**	**16**
Total Contact Hours		**32**			

Total credits to be earned for the award of M.Tech degree – 75

CONTACT HOUR/CREDIT:

L : Lecture Hours per week
T : Tutorial Hours per week
P : Practical Hours per week
C : Credit

PROGRAM ELECTIVES

COURSE CODE	NAME OF THE COURSE	L	T	P	C
NT2101	SOCIETAL IMPACTS OF NANOTECHNOLOGY	3	0	0	3
NT2102	NANOTECHNOLOGY IN HEALTH CARE	3	0	0	3
NT2103	NANOTECHNOLOGY IN ENERGY CONVERSION AND STORAGE	3	0	0	3
NT2104	NANOSCALE MAGNETIC MATERIALS AND DEVICES	3	0	0	3
NT2105	METALLOPOLYMER NANOCOMPOSITES	3	0	0	3
NT2106	NANOTOXICOLOGY	3	0	0	3
NT2107	GREEN MANUFACTURING TECHNOLOGY	3	0	0	3
NT2108	ADVANCED CRYSTAL GROWTH TECHNIQUES	3	0	0	3
NT2109	CARBON NANOTUBE ELECTRONICS AND DEVICES	3	0	0	3
NT2110	NANOSCALE INTEGRATED COMPUTING	3	0	0	3

NT2111	MICRO/NANO DEVICES AND SENSORS	3	0	0	3
NT2112	SPECTROSCOPIC TECHNIQUES FOR NANOMATERIALS	3	0	0	3
NT2113	CHEMISTRY OF NANOMATERIALS	3	0	0	3
NT2114	THIN FILM SCIENCE AND TECHNOLOGY	3	0	0	3
NT2115	MICRO/NANO COLLOIDS AND EMULSIONS	3	0	0	3
NT2116	NANOTECHNOLOGY BUSINESS APPLICATIONS AND COMMERCIALIZATION	3	0	0	3
NT2117	NANOTECHNOLOGY INTELLECTUAL PROPERTY RIGHTS AND INNOVATION	3	0	0	3
NT2118	NANO – CMOS CIRCUIT AND PHYSICAL DESIGN	3	0	0	3
NT2119	SOLID STATE TECHNOLOGY	3	0	0	3
NT2120	CELL AND MOLECULAR BIOLOGY	3	0	0	3
NT2121	NANOLITHOGRAPHY AND DEVICE FABRICATION	3	0	0	3
NT2122	STATISTICAL THERMODYNAMICS FOR NANOSYSTEMS	3	0	0	3
NT2123	QUANTUM MECHANICS FOR NANOTECHNOLOGY	3	0	0	3
NT2124	SCIENTIFIC RESEARCH METHODOLOGY	3	0	0	3

CORE COURSES

NT2001	**FUNDAMENTALS OF NANO SCIENCE AND NANO TECHNOLOGY**	**L**	**T**	**P**	**C**
	Total Contact hours: 60	**4**	**0**	**0**	**4**
	Prerequisite				
	Nil				

PURPOSE

The goal of this course is to provide an insight into the fundamentals of Nanoscience and nanotechnology. The course provides basics of nanomaterials, quantum mechanics and statistical mechanics

INSTRUCTIONAL OBJECTIVES

1.	To acquire the knowledge of basic sciences required to understand the fundamentals of Nanomaterials
2.	To acquire the knowledge of electronic, optical and magnetic properties of nanomaterials.
3	To get familiarize with the basic concepts of Statistical and Quantum mechanics

UNIT I - INTRODUCTION TO NANOTECHNOLOGY (12 hours)

Importance of Nanotechnology-History of Nanotechnology-Opportunity at the nano scale-length and time scale in structures-energy landscapes-Interdynamic aspects of inter molecular forces -classification based on the dimensionality- nanoparticles-nanoclusters-nanotubes-nanowires and nanodots- Semiconductor nanocrystals-carbon nanotubes- Influence of Nano structuring on Mechanical, optical, electronic, magnetic and chemical properties

UNIT II - BASICS OF QUANTUM MECHANICS (12 hours)

Introduction to Quantum Mechanics - Schrodinger equation – time dependent and time independent equations – Operators and observables - Commutation relations - Hermitian operators – Expectation values of observables - Solutions of the Schrodinger equation – free particle - particle in a box – one and three dimensions - particle in a finite well - Penetration through a barrier – Tunnel effect – Single step barrier.

UNIT III - STATISTICAL DESCRIPTION OF SMALL SYSTEMS (12 hours)

Quantum states and phase space, the density matrix, few examples; An ideal gas in quantum mechanical ensembles; statistics of occupation numbers. Basic concepts and thermodynamic behavior of an ideal Bose gas, Bose-Einstein condensation;

Discussion of a gas of phonons (The Debye field); Thermodynamics of an ideal fermi gas, heat capacity of a free-electron gas at low temperatures

UNIT IV - ELECTRON DYNAMICS IN SOLIDS (12 hours)

Free electron theory of metals, Band theory of solids, Bloch theorem – tight binding approximation- Kroning-Penne model, Evolution of band structure and Fermi surface-Metals and Insulators, Semiconductors-Transport properties- Mobility, Resistivity, Relaxation time, Recombination centers- Hall effects - Confinement and transport in nanostructure-Current, reservoirs, and electron channels-conductance formula for nanostructures- quantized conductance-Local density of states-Ballistic transport-Coulomb blockade-Diffusive transport-Fock space

UNIT V - CHEMISTRY ASPECTS OF NANOMATERIALS (12 hours)

Chemistry of small surfaces: Curvature and neighboring-charge effects on chemical reactivity and equilibria (pKa's, redox potentials)-Classical Colloid Theory: Nucleation and growth, Adsorption and Desorption Kinetics- Ostwald ripening- Homogeneous vs. heterogeneous nucleation- Anisotropic growth and shape control-Catalyzed (seeded) growth - Effect of Capping Agents on Growth Kinetics - self assembly and functionalization

REFERENCES

1. Pradeep.T "*A textbook of Nanoscience and Nanotechnology*", Tata McGraw – Hill education private ltd, 2012.
2. David. J, Griffiths, "*Introduction to Quantum Mechanics"*, Pearson, 2009.
3. Richard. L, Liboff, "*Introductory Quantum Mechanics"*, Pearson, 2003.
4. Keith stowe, "*An Introduction to Thermodynamics and Statistical Mechanics"*, Cambridge University, Newyork, 2007.
5. Claudine Herman, "*Statistical Physics"*, Springer, ,New York, 2005.
6. Kittel. C, "*Introduction to Solid State Physics",* Wiley India Pvt. Ltd., 2007.
7. Rao. C. N, Muller. A, Cheetham . A. K"*Nanomaterials chemistry*", Wiley-VCH, 2007.

NT2002	NANOSCALE MATERIALS: SYNTHESIS AND CHARACTERIZATION	L	T	P	C
	Total Contact hours: 75	3	0	2	4
	Prerequisite				
	Nil				

PURPOSE

The intended course covers the whole spectrum of nanomaterials ranging from overview, synthesis, properties, and characterization of nanophase materials.

INSTRUCTIONAL OBJECTIVES

1.	Beginners will be able to acquaint themselves with the excited subject though they are novice, whereas advanced learners will equip themselves to solve the complicated issues further.
2.	To know the importance of the synthesis method addressed in the material properties and give practical experience of nanomaterials synthesis/properties and characterization; investigations into the various factors influence the properties of nanomaterials, optimizing the procedures, and implementations to the new designs
3	To provide a sound understanding of the various concepts involved in fabrication of device architectures and able to evaluate them in advance

UNIT I - INTRODUCTION TO NANOSCALE SYSTEMS (9 hours)

Melting point and phase transition processes- quantum-size-effect (QSE). Size-induced metal-insulator-transition (SIMIT)- chemical physics of atomic and molecular clusters - Surface Energy - chemical potential as a function of surface curvature- Electrostatic stabilization- surface charge density Nanoparticles through homogeneous nucleation-Growth controlled by diffusion-growth controlled by surface process-influences of reduction reagents-solid state phase segregation - Electronic Structure of Nanoparticles- Kinetics in Nanostructured Materials

UNIT II - NANO FILM STRUCTURES & LITHOGRAPHY (9 hours)

Vapor deposition and different types of epitaxial growth techniques, Physical Vapor Deposition (PVD), pulsed laser deposition, Magnetron sputtering, Multi Beam Epitaxy, Chemical Vapor Deposition (CVD), Atomic Layer Deposition (ALD) - Micro lithography (photolithography, soft lithography, micromachining, e-beam writing, and scanning probe patterning).

UNIT III - CHEMICAL SYNTHESIS OF NANO MATERIAL (9 hours)

Self-assembly, self-assembled monolayers (SAMs). Langmuir-Blodgett (LB) films,

clusters, colloids, zeolites, organic block copolymers, emulsion polymerization, templated synthesis, and confined nucleation and/or growth. Biomimetic Approaches: polymer matrix isolation, and surface-templated nucleation and/or crystallization. Vapor (or solution) – liquid – solid (VLS or SLS) growth -Electrochemical Approaches: anodic oxidation of alumina films, porous silicon, and pulsed electrochemical deposition.

UNIT IV - CHARACTERIZATION OF NANOMATERIALS (9 hours)

X-ray Diffraction - Thermal Analysis Methods, Differential Thermal Analysis and Differential scanning calorimetry - Spectroscopic techniques, UV-Visible Spectroscopy – IR Spectroscopy – Microwave Spectroscopy - Raman Spectroscopy - Electron Spin Resonance Spectroscopy- - NMR Spectroscopy- Particle size characterization: Zeta Potential Measurement – Particle size Analysis – X-ray Photoelectron spectroscopy

UNIT V - IMAGING TECHNIQUES FOR NANOTECHNOLOGY (9 hours)

Fundamentals of the techniques – experimental approaches and data interpretation – applications/limitations of Optical microscopy - Scanning Electron Microscopy – Transmission Electron Microscopy – Atomic Force Microscopy – Scanning Tunneling Microscopy

LIST OF EXPERIMENTS (30 hours)

1. Processing and Development of Nanoparticle gas sensor
2. Magnetic separation/identification studies of nanoparticles
3. Harvesting light using nano-solar cells
4. Nano-Forensic analysis to identify, individualize and evaluate evidence using nanophase materials
5. Comparison of the performance of nanoparticles based conductive adhesives and conventional non conductive adhesives.
6. Electrodeposition and corrosion behavior of nanostructured composite film
7. Photocatalytic activity of nanomaterials

REFERENCES

1. Rao. C. N. R, Mu¨ller. A, Cheetham. A. K "*The Chemistry of Nanomaterials :Synthesis, Properties and Applications"*, Wiley-VCH, 2006.

2. Breachignac. C, Houdy. P, Lahmani. M, "*Nanomaterials and Nanochemistry"***,** Springer, 2006.

3. Guozhong Cao, **"***Nanostructures and Nanomaterials: Synthesis, Properties, and Applications"*, World Scientific Publishing Private, Ltd., 2011.

4. Zhong Lin Wang, "*Characterization Of Nanophase Materials"*, Wiley-VCH, 2004.
5. Carl. C Koch, "*Nanostructured Materials: Processing, Properties and Potential Applications",* William Andrew Publishing Norwich, 2006.

	METAMATERIALS AND NANOPHOTONICS	L	T	P	C
NT2003	Total Contact hours: 60	4	0	0	4
	Prerequisite				
	Nil				

PURPOSE

To introduce to the students the basic principles of Nanophotonics.

INSTRUCTIONAL OBJECTIVES

1.	To make the students acquainted with the concepts of Metamaterials and Nanophotonics.
2.	To describe the effects of quantization on the optical properties of semiconductors and metals.
3.	To determine the areas of opportunity in nanophotonic research.

UNIT I - FOUNDATIONS FOR NANOPHOTONICS (12 hours)

Photons and electrons: similarities and differences,freespace propagation. Confinement of photons and electrons. Propagation through a classicallyforbidden zone: tunneling. Localization under a periodic potential: Band gap. Cooperative effects for photons and electrons.Nanoscale optical interactions, axial and lateral nanoscopic localization.Nanoscale confinement of electronic interactions: Quantun confinement effects,nanoscale interaction dynamics, nanoscale electronic energy transfer. Cooperative emissions.

UNIT II - QUANTUM CONFINED MATERIALS (12 hours)

Inorganic semiconductors, quantum wells, quantum wires, quantum dots, quantum rings. Manifestation of quantum confinement: Optical properties nonlinear optical properties. Quantum confined stark effect. Dielectric confinement effect, superlattices.Core-shell quantum dots and quantum-dot-quantum wells. Quantum confinedstructures as Lasing media. Organic Quantum-confined structures

UNIT III - PLASMONICS AND METAMATERIALS (12 hours)

Introduction to Plasmonics and Metamaterials-Optical properties of metals - Surface plasmon polariton at metal/dielectric interface- Localized surface Plasmon-Extraordinary optical transmission mediated by surface Plasmon-Optical properties of

metal-dielectric composites-Electric and Magnetic Metamaterials- Negative index metamaterials- Applications of Metamaterials: Super-imaging; Transformation Optics and Invisibility Cloaks.

UNIT IV - PHOTONIC CRYSTALS (12 hours)

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

UNIT V - NEW APPROACHES IN NANOPHOTONICS (12 hours)

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

REFERENCES

1. Lucas Novotny and Bert Hecht, *"Principles of Nano-Optics"* ,Cambridge University Press, 2012.
2. Masuhara. H. Kawata. S and Tokunga. F "*NanoBiophotoics"*, Elsevier Science, 2007.
3. Saleh. B. E. A and Teich. A. C *"Fundamentals of Photonics"*, John Wiley and Sons, NewYork,1993.
4. Prasad. P. N"*Introduction to Biophotonics"*, John Wiley and Sons, 2003.
5. Ohtsu. M. Kobayashi. K. Kawazoe. T and Yatsui. T. "*Principals of Nanophotonics (Optics and Optoelectronics)"* University of Tokyo, Japan, 2003

NT2004	**NANOSCALE TECHNOLOGY IN BIOLOGICAL SYSTEMS**	**L**	**T**	**P**	**C**
	Total Contact hours: 75	**3**	**0**	**2**	**4**
	Prerequisite				
	Nil				

PURPOSE	
To provide an introduction to the theory and practice of bio-nanotechnology	
INSTRUCTIONAL OBJECTIVES	
1.	Understand the basic knowledge of Nanobiotechnology and DNA structures.
2.	Understand the application of Nanomaterials in biotechnology and acquire the knowledge about the DNA, proteins, amino acids, drug delivery, biomedicine etc.,
3	To provide the knowledge in basics of nanotechnology in biotechnology.
4.	To make the students understand about the functional principles of bionanotechnology

UNIT I - BIONANOMACHINES AND THEIR BASICS (9 hours)

Negligible gravity and inertia, atomic granularity, thermal motion, water environment and their importance in bionanomachines. The role of proteins- amino acids- nucleic acids- lipids and polysaccharides in modern biomaterials. Overview of natural Bionanomachines: Thymidylate Sythetase , ATP synthetase, Actin and myosin, Opsin, Antibodies and Collagen.

UNIT II - SYNTHESIS OF BIOMOLECULES & INTERPHASE SYSTEMS (9 hours)

Recombinant Technology, Site-directed mutagenesis, Fusion Proteins. Quantum Dot structures and their integration with biological structures. Molecular modeling tools: Graphic visualization, structure and functional prediction, Protein folding prediction and the homology modeling, Docking simulation and Computer assisted molecular design. Interphase systems of devices for medical implants – Microfluidic systems – Microelectronic silicon substrates – Nano-biometrics– Introduction – Lipids as nano-bricks and mortar: self assembled nanolayers.

UNIT III - FUNCTIONAL PRINCIPLES OF ANOBIOTECHNOLOGY (9 hours)

Information driven nanoassembly, Energetic, Role of enzymes in chemical transformation, allosteric motion and covalent modification in protein activity regulation, Structure and functional properties of Biomaterials, Bimolecular motors: ATP Synthetase and flagellar motors, Traffic across membranes: Potassium channels,ABC Transporters and Bactreriorhodapsin, Bimolecular sensing, Self

replication, Machine-Phase Bionanotechnology Protein folding; Self assembly, Self-organization, Molecular recognition and Flexibility of biomaterials.

UNIT IV - PROTEIN AND DNA BASED NANOSTRUCTUR (9 hours)

Protein based nanostructures building blocks and templates – Proteins as transducers and amplifiers of biomolecular recognition events – Nanobioelectronic devices and polymer nanocontainers– Microbial production of inorganic nanoparticles – Magnetosomes .DNA based nanostructures– Topographic and Electrostatic properties of DNA and proteins – Hybrid conjugates of gold nanoparticles – DNA oligomers – Use of DNA molecules in nanomechanics and Computing.

UNIT V - APPLICATIONS OF NANOBIOTECHNOLOGY (9 hours)

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

LIST OF EXPERIMENTS (30 hours)

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

REFERENCES

1. Niemeyer.C.M. Mirkin C. A "*Nanobiotechnology: Concepts, Applications and Perspectives*", Wiley – VCH, 2004.
2 Pradeep. T "*Nano: The Essentials*", McGraw – Hill education, 2007.
3. Challa. S.S.R, Kumar, Josef Hormes, Carola Leuschaer, "*Nanofabrication Towards Biomedical Applications, Techniques, Tools, Applications and Impact*", Wiley – VCH, 2005.
4. Nicholas. A, Kotov, "*Nanoparticle Assemblies and Superstructures*", CRC, 2006.
5. David. S, Goodsell*, "Bionanotechnology*", John Wiley & Sons, 2004.

NT2005	MOLECULAR AND NANOELECTRONICS	L	T	P	C
	Total Contact Hours - 75	3	0	2	4
	Prerequisite				
	Nil				

PURPOSE

The purpose of this course is to develop broader aspects in understanding the role of nanoelectronics and its application.

INSTRUCTIONAL OBJECTIVES

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

UNIT I - QUANTUM DEVICES (9 hours)

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

UNIT II - NANOELECTRONIC DEVICES (9 hours)

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

UNIT III - MOLECULAR NANOELECTRONICS (9 hours)

Electronic and optoelectronic properties of molecular materials - Electrodes & contacts – functions– molecular electronic devices - elementary circuits using organic molecules- Organic materials based rectifying diode switches – TFTs- OLEDs- OTFTs – logic switches.

UNIT IV - SPINTRONICS (9 hours)

Spin tunneling devices - Magnetic tunnel junctions- Tunneling spin polarization - Giant tunneling using MgO tunnel barriers - Tunnel-based spin injectors - Spin injection

and spin transport in hybrid nanostructures - spin filters -spin diodes - Magnetic tunnel transistor - Memory devices and sensors - ferroelectric random access memory-MRAMS -Field Sensors - Multiferro electric sensors- Spintronic Biosensors.

UNIT V - NANOELECTRONIC ARCHITECTURES AND COMPUTATIONS (9 hours)

Architecture Principles: Mono and Multi processor systems – Parallel data processing – Power Dissipation and Parallelism – Classic systolic arrays - Molecular devices-properties - Self-organization – Size dependent -limitations. Computation: Monte Carlo Simulations- Computational methods and Simulations from ab initio to multiscale Modeling- Modeling of Nanodevices.

LIST OF EXPERIMENTS (30 hours)

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

REFERENCES

1. Mitin. V. Kochelap V, Stroscio. M "*Introduction to Nanoelectronics*", Cambridge University Press, 2008.
2. Rainer Waser, "*Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices*", Wiley-VCH, 2003.
3. Karl Goser, Peter Glosekotter, Jan Dienstuhl, "*Nanoelectronics and Nanosystems*", Springer, 2004.
4. Sadamichi Maekawa, "*Concepts in Spin Electronics*", Oxford University Press, 2006.
5. Banyai. L and Koch. S.W "*Semiconductor Quantum Dots*", World Scientific, 1993.
6. Edward. L, Wolf, "*Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience*", Wiley-VCH, 2006.

NT2006	INDUSTRIAL TRENDS AND APPLICATIONS OF NANOTECHNOLOGY	L	T	P	C
	Total Contact Hours - 60	4	0	0	4
	Prerequisite				
	Nil				

PURPOSE	
To provide knowledge of various industrial applications of nanotechnology.	
INSTRUCTIONAL OBJECTIVES	
1.	To elucidate on advantages of nanotechnology based applications in industries
2.	To provide instances of contemporary industrial applications of nanotechnology
3.	To provide an overview of future technological advancements and increasing role of nanotechnology in industries

UNIT I - NANOTECHNOLOGY IN ELECTRONICS AND ENERGY (12 hours)

Miniaturization- Nano electronic devices and circuits – Semiconductor Memories - Dynamic Radom Access Memory- Nonvolatile Semiconductor Memories- Quantum Dot based Memory Cell- Sensors; physical and chemical- Electronic noses- Actuators- Micro and Nano-Electromechanical systems– Lighting and Displays – Quantum optical devices- Lasers – Batteries – Super capacitors- Fuel cells–role of nanomaterials in fuel cell applications- Photovoltaic cells –Application of nanotechnology in solar cells- Application of power in transportation including space

UNIT II - NANOTECHNOLOGY IN BIOMEDICAL INDUSTRY (12 hours)

Nanoparticles and Micro–organism- Biosensors- Bioreceptors and their properties - Biochips- Integrated nanosensor networks for detection and response- DNA based biosensors and diagnostics- Natural nanocomposite systems; spider silk, bones, shells - Nanomaterials in bone substitutes and dentistry – Implants and Prosthesis – Tissue Engineering – Neuroscience -Neuro-electronic Interfaces -Nanorobotics– Photodynamic Therapy - Protein Engineering – Nanosensors in Diagnosis–Drug delivery – Cancer therapy and other therapeutic applications.

UNIT III - NANOTECHNOLOGY IN AGRICULTURE AND FOOD SECTO (12 hours)

Nanotechnology in Agriculture -Precision farming, Smart delivery systems – Insecticides using nanotechnology – Potential of nano-fertilizers – Potential benefits in Nanotechnology in Food industry – Global Challenges- Product innovation and Process improvement- Consumer benefits- Food processing - Packaging- - Packing materials; physical properties- Improvements of mechanical and barrier properties- Antimicrobial functionality- Active packaging materials- -Information and communication technology- Sensors- RF identification- Food safety- Nanomaterial

based Food diagnostics – Contaminant detection – Intelligent packaging- Nanoengineered Food ingredients- Potential risks to Nanofood to consumers

UNIT IV - NANOTECHNOLOGY IN TEXTILES AND COSMETICS (12 hours)

Nanofibre production – Electrospinning and charge injectionmethod – morphological control- yarns and polymide nanofibers- Carbon Nanotube and Nanofibre Reinforced Polymer Fibres- multifunctional polymer nanocomposites- Improvement of polymer functionality- Nylon-6 nanocomposites from polymerization- Dyeable Polypropylene - nanocoatings and surface modifications - Nano-filled polypropylene fibers - UV resistant, antibacterial, self-cleaning, flame retardant textiles – Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof, Cleaner kids clothes, Wired and Ready to Wear textiles- Cosmetics; Formulation of Gels, Shampoos, Hair-conditioners–Nanomaterials in Sun-screen UV protection – Color cosmetics

UNIT V - NANOTECHNOLOGY IN DEFENCE AND AEROSPACE (12 hours)

Pathways to Physical protection- Detection and diagnostics of chemical and biological agents, methods- Chemical and Biological counter measures- Decontamination- Post exposure and pre exposure protection and decontamination- Nanotechnology enabled bio chemical weapons- Influence operations- Evasion of medical countermeasures- Nanotechnology based satellite communication system- Guidance, Navigation and control- Spacecraft thermal control- mini, micro, nanosatellite concepts- Fiber optic and Chemical microsensors for space craft and launch support- Micro/Nano pressure and temperature sensors for space missions.

REFERENCES

1. Mark. A, Ratner and Daniel Ratner, "*Nanotechnology: A Gentle Introduction to the Next Big Idea",* Pearson, 2003.
2. Bharat Bhushan, "*Springer Handbook of Nanotechnology",* Barnes & Noble 2004.
3. Neelina. H, Malsch (Ed.), "*Biomedical Nanotechnology",* CRC Press 2005.
4. Udo. H, Brinker, Jean-Luc Mieusset (Eds.), "*Molecular Encapsulation: Organic Reactions in Constrained Systems",* Wiley Publishers 2010.
5. Jennifer Kuzma and Peter Ver Hage, "*Nanotechnology in agriculture and food production",* Woodrow Wilson International Center, 2006.
6. Lynn. J, Frewer, Willehm Norde. R. H, Fischer and Kampers. W. H "*Nanotechnology in the Agri- food sector",* Wiley-VCH Verlag, 2011.
7. Brown. P. J and Stevens. K "*Nanofibers and Nanotechnology in Textiles",* Woodhead Publishing Limited, Cambridge, 2007.

8. Mai. Y-W "*Polymer Nano composites",* Woodhead publishing, 2006.
9. Chang. W.N "*Nanofibres fabrication, performance and applications",* Nova Science Publishers Inc, 2009.
10. Helvajian. H and. Robinson. E.Y *"micro and nanotechnology for space systems"* the aerospace corporation, Micrograph , 1997.
11. Margaret. E, Kosal, *"Nanotechnology for Chemical and Biological defence*, Springer 2009.

NT2047	SEMINAR	L	T	P	C
		0	0	1	1
PURPOSE					
To train the students in preparing and presenting technical topics.					
INSTRUCTIONAL OBJECTIVE					
The student shall be capable of identifying topics of interest related to the program of study and prepare and make presentation before an enlightened audience.					

The students are expected to give at least two presentations on their topics of interest which will be assessed by a committee constituted for this purpose. This course is mandatory and a student has to pass the course to become eligible for the award of degree. Marks will be awarded out of 100 and appropriate grades assigned as per the regulations.

NT2048	**INDUSTRIAL TRAINING (Training to be undergone after II semester)**	**L**	**T**	**P**	**C**
	3 week practical training in industry	**0**	**0**	**1**	**1**
	Prerequisite				
	Nil				

PURPOSE	
To provide practical exposure in Nano Technology related organizations.	
INSTRUCTIONAL OBJECTIVES	
1.	Students have to undergo three – week practical training in Nano Technology related organizations so that they become aware of the practical applications of theoretical concepts studied in the class rooms.

Students have to undergo three-week practical training in Nano Technology related organizations of their choice but with the approval of the department. At the end of the training student will submit a report as per the prescribed format to the department.

Assessment process

This course is mandatory and a student has to pass the course to become eligible for the award of degree. The student shall make a presentation before a committee constituted by the department which will assess the student based on the report submitted and the presentation made. Marks will be awarded out of 100 and appropriate grades assigned as per the regulations.

NT2049		L	T	P	C
	PROJECT WORK PHASE I (III semester)	**0**	**0**	**12**	**6**
NT2050	**PROJECT WORK PHASE II (IV semester)**	**0**	**0**	**32**	**16**
PURPOSE					
To undertake research in an area related to the program of study					
INSTRUCTIONAL OBJECTIVE					
The student shall be capable of identifying a problem related to the program of study and carry out wholesome research on it leading to findings which will facilitate development of a new/improved product, process for the benefit of the society.					

M.Tech projects should be socially relevant and research oriented ones. Each student is expected to do an individual project. The project work is carried out in two phases – Phase I in III semester and Phase II in IV semester. Phase II of the project work shall be in continuation of Phase I only. At the completion of a project the student will submit a project report, which will be evaluated (end semester assessment) by duly appointed examiner(s). This evaluation will be based on the project report and a viva voce examination on the project. The method of assessment for both Phase I and Phase II is shown in the following table:

Assessment	Tool	Weightage
In- semester	I review	10%
	II review	15%
	III review	35%
End semester	Final viva voce examination	40%

Student will be allowed to appear in the final viva voce examination only if he / she has submitted his / her project work in the form of paper for presentation / publication in a conference / journal and produced the proof of acknowledgement of receipt of paper from the organizers / publishers.

SUPPORTIVE COURSE

	APPLIED MATHEMATICS TO NANOTECHNOLOGISTS	L	T	P	C
MA2018	Total Contact hours: 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

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

INSTRUCTIONAL OBJECTIVES

1.	To understand Mathematical and Statistical concepts and apply the concepts in solving the engineering problems.
2.	To familiarize with the applications of differential equations.
3.	To apply the sampling theory to engineering problems

UNIT I - ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS (9 hours)

Simultaneous first order linear equations with constant co-efficients – linear equations of second order with constant and variable co-efficients – Formation of partial differential equations – Classification of second order partial differential equations

UNIT II - VECTOR CALCULUS (9 hours)

Gradient, divergence, curl – Solenoidal and irrotational fields – Vector identitites (without proof)–Directional derivatives – Line, surface and volume integrals – Statements of Green's' Gauss divergence and Stroke's theorems only – Verification and applications to cubes and parallelepipeds only.

UNIT III - FOURIER TRANSFORMS (9 hours)

Statement of Fourier integral theorem – Fourier transform pairs – Properties of Fourier transforms–Transforms of simple functions – Application to 1-D heat conduction problems.

UNIT IV - PROBABILITY THEORY (9 hours)

Probability - basic definition, conditional, Probability, Baye's theorem - Binomial, Poisson, Normal - Random variable, continuous random variable - Probability density function, average, variance.

UNIT V - SAMPLING THEORY **(9 hours)**

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

REFERENCES

1. Sankara Rao K, "*Introduction to Partial Differential Equations",* PHI, New Delhi, 2003.
2. Gupta. S.C, and Kapoor. V.K, *"Fundamentals of Mathematical Statistics*", Sultan Chand and Sons, New Delhi, 1999.
3. Kapoor. V.K, *"Statistics (Problems and Solutions)"*, Sultan Chand and Sons, New Delhi, 1994.
4. Montgomery. D.C and Johnson. L.A, "*Forecasting and Time Series"*, Mc Graw Hill, 2001.
5. Anderson. O.D, "*Time Series Analysis: Theory and Practice*", I. North-Holland, Amsterdam, 1982.

PROGRAM ELECTIVE COURSES

NT2101	SOCIETAL IMPACTS OF NANOTECHNOLOGY	L	T	P	C
	Total Contact Hours – 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

To provide an adequate basic knowledge on social impact of nanoscience and nanotechnology.

INSTRUCTIONAL OBJECTIVES

1.	To provide awareness to the engineering students about socio economic impact of nanotechnology and to handle the techniques effectively.
2.	Understand the various social impacts of nanotechnology trend and research.
3.	To enhance the nanotechnology research by taking ethics and public opinion into consideration.
4.	To understand of professional and ethical responsibility

UNIT I - PROTECTION & REGULATION FOR NANOTECHNOLOGY (9 hours)

Patentability requirements-riding the patent office pony-infringement issues-nanotech patents outside the united states-copyright requirements-nanotech creation as artist works-Delegation of power of agencies-Examples of regulation of nanotechnology-environmental regulations-regulation of exports-political and judicial control over agency action.

UNIT II – LIABILITY LEGAL ASPECTS OF NANOTECHNOLOGY (9 hours)

The applications of civil &criminal laws-civil liability, application of negligence to nanotechnology, strict liability for nanotechnology products-warranty-class actions-nanotechnology business organization-criminal liability

UNIT III – ECONOMIC IMPACTS AND COMMERCIALIZATION OF NANOTECHNOLOGY & SOCIAL SCENARIOS (9 hours)

Introduction -Socio-Economic Impact of Nanoscale Science: Initial Results and Nanobank-Managing the Nanotechnology Revolution: Consider the Malcolm Baldrige National Quality Criteria -The Emerging NanoEconomy: Key Drivers, Challenges, and Opportunities-Transcending Moore's Law with Molecular Electronics and Nanotechnology- Navigating Nanotechnology Through Society -Nanotechnology, Surveillance, and Society: Methodological Issues and Innovations for Social Research-Nanotechnology: Societal Implications: Individual Perspectives-Nanotechnology and Social Trends-Five Nanotech

UNIT IV - ETHICS, LAW & GOVERNANCE (9 hours)

Ethics and Law**-**Ethical Issues in Nanoscience and Nanotechnology: Reflections and Suggestions-Ethics and Nano: A Survey-Law in a New Frontier- An Exploration of Patent Matters Associated with Nanotechnology -The Ethics of Ethics -Negotiations over Quality of Life in the Nanotechnology Initiative. Governance**-**Problems of Governance of Nanotechnology -Societal Implications of Emerging Science and Technologies: A Research Agenda for Science and Technology Studies (STS)-Institutional Impacts of Government Science Initiatives -Nanotechnology for National Security.

UNIT V - PUBLIC PERCEPTIONS & EDUCATION (9 hours)

Public Perceptions**-**Societal Implications of Nanoscience: An Agenda for Public Interaction Research -Communicating Nanotechnological Risks- A Proposal to Advance Understanding of Nanotechnology's Social Impacts -Nanotechnology in the Media: A Preliminary Analysis-Public Engagement with Nanoscale Science and Engineering -Nanotechnology: Moving Beyond Risk-Communication Streams and Nanotechnology: The (Re)Interpretation of a New Technology- Nanotechnology: Societal Implications — Individual Perspectives-Historical Comparisons for Anticipating Public Reactions to Nanotechnology.

REFERENCES

1. Mihail. C, Roco and William Sims Bainbridge "*Nanotechnology: Societal Implications II-Individual Perspectives*", Springer ,2007.
2. Geoffrey Hunt and Michael. D, Mehta "*Nanotechnology: Risk, Ethics and Law*", Earthscan/James & James publication ,2006.
3. Jurgen Schulte "*Nanotechnology: Global Strategies, Industry Trends and Applications*", John Wiley & Sons Ltd ,2005.
4. Mark. R, Weisner and Jean-Yves Bottero "*Environmental Nanotechnology applications and impact of nanomaterial*", The McGraw-Hill Companies,2007.

	NANOTECHNOLOGY IN HEALTH CARE	L	T	P	C
NT2102	Total Contact Hours – 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

Nanotechnology for health care involves the development and application of materials and devices to study biological processes and to treat disease at the level of single molecules and atoms

INSTRUCTIONAL OBJECTIVES

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

UNIT I - NANOMOLECULAR DIAGNOSTICS - ARRAY AND CHIPS (9 hours)

Introduction - Nanodiagnostics -Rationale of Nanotechnology for Molecular Diagnostics -Nanoarrays for Molecular Diagnostics . NanoProTM System - Nanofluidic/Nanoarray Devices to Detect a Single Molecule of DNA-Self-Assembling Protein Nanoarrays -Fullerene Photodetectors for Chemiluminescence Detection on Microfluidic Chips -Protein Microarray for Detection of Molecules with Nanoparticles Protein Nanobiochip Nanoparticles for Molecular Diagnostics -Gold Nanoparticles - Quantum Dots for Molecular Diagnostics Magnetic Nanoparticles -Use of Nanocrystals in Immunohistochemistry -Imaging Applications of Nanoparticles Study of Chromosomes by Atomic Force Microscopy-Applications of Nanopore Technology for Molecular Diagnostics DNA–Protein and DNA–Nanoparticle Conjugates

UNIT II - NANOMACHINES AND NANOBARCODES, NANOBIOSENSO (9 hours)

DNA Nanomachines for Molecular Diagnostics -Nanobarcodes Technology - Nanobarcode Particle Technology for SNP Genotyping -Qdot Nanobarcode for Multiplexed Gene Expression Profiling-Biobarcode Assay for Proteins Single-Molecule Barcoding System for DNA Analysis Nanoparticle-Based Colorimetric DNA Detection Method Cantilevers as Biosensors for Molecular Diagnostics –Carbon Nanotube Biosensors -FRET-Based DNA Nanosensors. Ion Channel Switch Biosensor Technology -Electronic Nanobiosensors -Electrochemical Nanobiosensors -Quartz Nanobalance Biosensors -Viral Nanosensors –PEBBLE Nanosensors - Microneedle- Mounted Biosensors Optical Biosensors- Nanowire (NW) Biosensors - Nanoscale Erasable Biodetectors.

UNIT III - NANOPHARMACEUTICALS (9 hours)

Introduction -Nanobiotechnology for Drug Discovery -Gold Nanoparticles for Drug Discovery - Use of Quantum Dots for Drug Discovery -Nanolasers for Drug Discovery -Cells Targeting by Nanoparticles with Attached Small Molecules -Role of AFM for Study of Biomolecular Interactions for Drug Discovery Nanoscale Devices for Drug Discovery -Nanotechnology Enables Drug Design at Cellular Level Nanobiotechnology-Based Drug Development -Dendrimers as Drugs- Fullerenes as Drug Candidates -Nanobodies Nanobiotechnology in Drug Delivery – Nanoscale Delivery of Therapeutics -Nanosuspension Formulations Viruses as Nanomaterials for Drug Delivery -Nanoparticle-Based Drug Delivery -Trojan Nanoparticles -Self-Assembling Nanoparticles for Intracellular Drug Delivery - Nanoparticle Combinations for Drug Delivery Liposomes -Liposome–Nanoparticle Hybrids-Nanospheres-Nanotubes -Nanocochleates.-Nanomolecular Valves for Controlled Drug Release - Nanomotors for Drug Delivery.

UNIT IV - ROLE OF NANOTECHNOLOGY IN BIOLOGICAL THERAPIES (9 hours)

Introduction - Development of nano medicines – Nano Shells – Nano pores – Tectodendrimers– Nanoparticle drug system for oral administration – Drug system for nasal administration – Drug system for ocular administration – Nanotechnology in diagnostic application. Preformulation Studies: on various dosage forms such as tablets, capsules, suspension, creams, emulsion, injectables, ophthalmic and aerosols etc. Biomedical nanoparticles – Liposome's – Dentrimers – Different types of drug loading – Drug release – Biodegradable polymers – Applications Nanobiotechnologies for Single-Molecule Detection -Protease-Activated QuantumDot Probes -Nanotechnology for Point-of-Care Diagnostics -Nanodiagnostics for the Battle Field -Nanodiagnostics for Integrating Diagnostics with Therapeutics

UNIT V - APPLICATION IN CANCER THERAPY & NANOMEDICINE (9 hours)

Introduction and Rationale for Nanotechnology in Cancer Therapy -- Passive Targeting of Solid Tumors: Pathophysiological Principles and Physicochemical Aspects of Delivery Systems -Active Targeting Strategies in Cancer with a Focus on\Potential Nanotechnology Applications-Pharmacokinetics of Nanocarrier-Mediated Drug and Gene Delivery - Multifunctional Nanoparticles for Cancer Therapy- Neutron Capture Therapy of Cancer: Nanoparticles and High Molecular Weight Boron Delivery Agents. Nano-Oncology- Nanoneurology- Nanocardiology- Nano-Orthopedics- Nano-Ophthalmology

REFERENCES

1. Kewal. K, Jain ," *The Handbook of Nanomedicine* "Humana Press, 2008.
2. Zhang, "*Nanomedicine: A Systems Engineering Approach"* ,Pan Stanford Publishing, 2005.
3. Robert. A, Freitas Jr., "*Nanomedicine Volume IIA: Biocompatibility*", Landes Bioscience Publishers, 2003.

	NANOTECHNOLOGY IN ENERGY CONVERSION AND STORAGE	L	T	P	C
NT2103	Total Contact Hours - 45	**3**	**0**	**0**	**3**
	Prerequisite				
	Nil				

PURPOSE

The purpose of this course is an introduction to various forms of energy used in industries and methods of converting from one form to another by using Nanotechnology. Students should be provided with the opportunity to explore these various forms of energy, particularly in terms of Nanotechnology and how they are converted and how their use impact on the environment.

INSTRUCTIONAL OBJECTIVES

1.	To demonstrate knowledge of the sources of energy and the methods of energy Conversion in Nanotechnology.
2.	To appreciate the role of Nano technology in energy and its efforts to improve lifestyle.
3.	Understand the basic principles of Renewable Energy technology, Micro Fuel Cell Technology and Micro Fluid System.
4.	To conduct experiments to verify basic principles of energy conversion.

UNIT I - INTRODUCTION (9 hours)

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

UNIT II - RENEWABLE ENERGY TECHNOLOGY (9 hours)

Energy challenges, development and implementation of renewable energy technologies- nanotechnology enabled renewable energy technologies -Energy transport, conversion and storage- Nano, micro, and poly crystalline and amorphous Si for solar cells, Nano-micro Si-composite structure, various techniques of Si deposition.

UNIT III - MICRO FUEL CELL TECHNOLOGY (9 hours)

Micro-fuel cell technologies, integration and performance for micro-fuel cell systems - thin film and microfabrication methods - design methodologies - micro-fuel cell power sources.

UNIT IV - MICROFLUIDIC SYSTEMS (9 hours)

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

UNIT V - HYDROGEN STORAGE METHODS (9 hours)

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

REFERENCES

1. Twidell. J. and Weir. T "*Renewable Energy Resources"*, E & F N Spon Ltd, 1986.
2. Martin A Green, "*Solar cells: Operating principles, technology and system applications"*, Prentice Hall Inc, Englewood Cliffs, 1981.
3. Moller. H J "*Semiconductor for solar cells"*, Artech House Inc, 1993.
4. Ben G Streetman, "*Solid state electronic device"*, Prentice Hall of India Pvt Ltd.,1995.
5. Kettani. M.A "*Direct energy conversion",* Addision Wesley Reading, 1970.
6. Linden , "*Hand book of Batteries and fuel cells"*, Mc Graw Hill, 1984.
7. Hoogers , "*Fuel cell technology handbook"*. CRC Press, 2003.
8. Vielstich, *"Handbook of fuel cells: Fuel cell technology and applications"*, Wiley, CRC Press, 2003.

	NANOSCALE MAGNETIC MATERIALS AND DEVICES	L	T	P	C
NT2104	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

To explore the relationship between the performance of magnetic devices and the microstructural characteristics of the materials from which they are constructed. Nanometer-sized magnetic particles feature a device-motivated approach that places strong emphasis on emerging technologies including magnetic data storage and spintronics.

INSTRUCTIONAL OBJECTIVES

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

UNIT I - INTRODUCTION (9 hours)

Magnetic fundamentals –Antiferromagnetic materials – Domains and the magnetization process– Coercivity of fine particles – Super paramagnetism in fine particles – Exchange anisotropy - Induced anisotropy in thin films – Electron transport in magnetic multi-layers – Spin polarized electron tunneling – Interlayer exchange coupling – Spin relaxation in magnetic metallic layers and multi-layers - Non-equilibrium spin dynamics in laterally defined magnetic structures

UNIT II - NANOMAGNETISM (9 hours)

Two-spin channel model - Two terminal spin electronics – Three terminal spin electronics - Spin tunneling - Study of ferromagnetic and antiferromagnet interfaces – Photoemission Electron Microscopy - X-ray Absorption Spectroscopy - X-ray Magnetic Linear Dichroism (XMLD) - X-ray Magnetic Circular Dichroism (XMCD) - Temperature dependence of X-ray Magnetic Dichroism

UNIT III - FABRICATION AND IMAGING (9 hours)

Molecular nanomagnets – Mesoscopic magnetism - Particulate nanomagnets – Geometrical nanomagnets – Fabrication techniques scaling – Characterization using various techniques – Imaging magnetic microspectroscopy – Optical Imaging – Lorentz Microscopy – Electron Holography of Magnetic Nanostructures –Magnetic Force Microscopy.

UNIT IV - MAGNETIC DATA STORAGE AND RECORDIN (9 hours)

Magnetic data storage – Disk formatting – Partitioning – Hard disk features – Hard disk data transfer modes – Programmed I/O – Direct memory access – Ultra DMA – Data addressing – Standard CHS addressing – Extended CHS addressing – Logical Block Addressing – Magnetic recording- Principles of magnetic recording - Magnetic digital recording - Perpendicular recording - Magneto-Optic recording - Magnetic media – Kerr effect – Faraday effect

UNIT V - MAGNETIC STRUCTURES AND APPLICATION (9 hours)

Magnetic sensors and Giant Magnetoresistance - Optically transparent materials - Soft ferrites- Nanocomposite magnets - Magnetic refrigerant – High TC superconductor – Ferro/biofluids– Biomedical applications of magnetic nanoparticles - Diagnostic applications - Therapeutic applications - Physiological aspects - Toxic effects

REFERENCES

1. Hans .P.O, and Hopster. H, "*Magnetic Microscopy of Nanostructures*", Springer ,2004.
2. Bland. J.A.C, and B. Heinrich. B, "*Ultra thin Magnetic Structures III – Fundamentals of Nanomagnetism*", Springer ,2004.
3. Nicola. A.S, "*Magnetic Materials: Fundamentals and Device Applications*", Cambridge University Press ,2003.

NT2105	METALLOPOLYMER NANOCOMPOSITES	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

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

INSTRUCTIONAL OBJECTIVES

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

UNIT I - NANOPARTICLES IN MATERIALS CHEMISTRY AND IN THE NATURAL SCIENCES (9 hours)

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

UNIT II - PRINCIPLES AND MECHANISMS OF NANOPARTICLE STABILIZATION BY POLYMERS (9 hours)

Stability of nanoparticles in solutions – Stabilizing capability characteristics of polymers– Characteristics of polymer absorption on metal surfaces specifics of polymer surfactants as stabilizers – Mechanism of nanoparticles stabilization by polymers – Stabilization of nanoparticles by electrolytes – Surface proofing as a method of stabilizing nanoparticles by polymers on the problem of matrix confinement

UNIT III - SYNTHETIC METHODS FOR METALLO-POLYMER (9 hours)

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

UNIT IV - PHYSICO-CHEMICAL METHODS FOR METALLO-POLYMER NANOCOMPOSITE PRODUCTION (9 hours)

Cryochemical methods of atomic metal deposition on polymers – Metal evaporation methods on polymers localized at room temperature – Synthesis of nanocomposites in a plasma-chemical process – Radiolysis in polymer solutions – Photolysis of metal-polymer systems as means of obtaining nanocomposites – Electrochemical methods of nanocomposite formation – General characteristics of sol-gel reactions – A combination of polymerization reactions and in situ sol-gel synthesis of nanocomposites – Sol-gel synthesis in the presence of polymers – Morphology and fractal model of Hybrid nanocomposites – Nanocomposites incorporating multi-metallic ceramics – Intercalation process – Polymerization into the basal space – Macromolecules introduction into the layered host lattices – Intercalation nanocomposites of polymer/metal chalcogenide type – Langmuir-Blodgett metallopolymers films as self organized hybrid nanocomposites

UNIT V - NANOBIOCOMPOSITES (9 hours)

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

REFERENCES

1. Candau. C. F and Ottewill. R. H "*An introduction to polymer colloids*", Springer Berlin Heidelberg, New York, 2005.
2. Pomogailo. A. D and Savostyanov. V. S "*Synthesis and polymerization of metal containing monomers*" CRC press, 1994.

NT2106	**NANOTOXICOLOGY**	**L**	**T**	**P**	**C**
	Total Contact Hours - 45	**3**	**0**	**0**	**3**
	Prerequisite				
	Nil				

PURPOSE

To learn and understand social impact and health issues of environmental pollution caused due to nanoindustries.

INSTRUCTIONAL OBJECTIVES

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

UNIT I - POSSIBLE HEALTH IMPACT OF NANOMATERIALS (9 hours)

Sources of Nanoparticles; Epidemiological Evidence; Entry Routes into the Human Body – Lung, Intestinal Tract, Skin*;* Nano particle Size - Surface and Body Distribution; Effect of Size and Surface Charges; Nanoparticles, Thrombosis and Lung Inflammation ;Nanoparticles and Cellular Uptake; Nanoparticles and the Blood-Brain Barrier.

UNIT II - NANOMATERIALS FOR ENVIRONMENTAL REMEDIATION (9 hours)

Introduction- Nanoparticle-based Remediation Materials - Acid-Base Chemistry - Redox Chemistry- Field Deployments of ZVI - Absorption Chemistry - Hybrid Nanostructured Remediation Materials- Self-assembled Monolayers on Mesoporous Supports (SAMMS) - Functional CNTs .

UNIT III - BIOTOXICITY OF METAL OXIDE NANOPARTICLES AND CARBON NANOTUBES (9 hours)

Introduction; Nanoparticles in the Environment; Nanoparticles in Mammalian Systems; Health Threats; Nanomaterials and Biotoxicity; Iron Oxide; Titanium Dioxide; Dark Studies; UV Irradiation Studies;Other Metal Oxides; Toxicological Studies and Toxicity of Manufactured CNTs- case study; Toxicity of CNTs and Occupational Exposure Risk; Toxicity of MWCNTs/SWCNTs and Impact on Environmental Health.

UNIT IV - TOXICOLOGY OF NANOPARTILES IN ENVIRONMENTAL POLLUTION **(9 hours)**

Air Pollution; Introduction to Air Pollution Particles; Adverse Effects of PM in Epidemiological Studies; Role of Nanopartides in Mediating the Adverse Pulmonary Effects of PM; Effects of Nanopartides on the Cardiovascular System; Nanopartide Translocation and Direct Vascular Effects; Endothelial Dysfunction and Endogenous Fibrinolysis; Coagulation and Thrombosis; Cardiac Autonomie Dysfunction; Effects of Nanopartides on the Liver and Gastrointestinal Tract; Effects of NP on the Nervous System.

UNIT V - DOSIMETRY, EPIDEMIOLOGY AND TOXICOLOGY OF NANOPARTICLES **(9 hours)**

Epidemiological Evidence for Health Effect Associations with Ambient Particulate Matter; Toxicological Evidence for Ambient Particulate Matter Induced Adverse Health Effects; Inhaled Nanoparticle Dosimetry; Toxicological Plausibility of Health Effects Caused by Nanoparticles;Integrated Concept of Risk Assessment of Nanoparticles.

REFERENCES

1. Challa. S. S. R, Kumar, "*Nanomaterials - Toxicity, Health and Environmental Issues*", Wiley-VCH publisher, 2006.
2. Nancy. A, Monteiro-Riviere, Lang Tran. C, "*Nanotoxicology: Characterization, Dosing and Health Effects*", Informa healthcare, 2007.
3. Drobne. D, "*Nanotoxicology for safe and Sustainable Nanotechnology*", Dominant publisher, 2007.
4. Zafar Nyamadzi. M, "*A Reference handbook of nanotoxicology*", Dominant publisher, 2008.

NT2107	GREEN MANUFACTURING TECHNOLOGY	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

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

INSTRUCTIONAL OBJECTIVES

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

UNIT I - GREENER NANOSYNTHESIS (9 hours)

Greener Nanosynthesis: Greener Synthetic Methods for Functionalized Metal Nanoparticles, Greener Preparations of Semiconductor and Inorganic Oxide Nanoparticles, green synthesis of Metal nanoparticles, Nanoparticle characterization methods.

UNIT II - NANOMATERIALS FOR "GREEN" SYSTEMS (9 hours)

Green materials, including biomaterials, biopolymers, bioplastics, and composites Nanotech Materials for Truly Sustainable Construction: Windows, Skylights, and Lighting. Paints, Roofs, Walls, and Cooling. Multifunctional Gas Sensors, Biomimetic Sensors, Optical Interference Sensors Thermo-, light-, and stimulus-responsive smart materials Nanomaterials

UNIT III - NANOMATERIALS FOR ALTERNATIVE ENERGY (9 hours)

Nanomaterials for Fuel Cells and Hydrogen Generation and storage, Nanostrcutures for efficient solar hydrogen production,.Nanomaterials for Solar Thermal Energy and Photovoltaic. Semiconductor Nanocrystals and Quantum Dots for Solar Energy Applications Nanoparticles for Conducting Heat Transfer

UNIT IV - NANOTECHNOLOGY IN REMEDIATION (9 hours)

Nanoremediation: Identification and characterization of Hazardous waste, Nano Pollution, Air- Water - Soil Contaminants, Identification and Characterization of Organic and inorganics, Environmental cleanup technologies. Nanomaterials-Remediation: Nano Membranes, Nano Meshes, Nano Fibres, Nano Clays and Adsorbents, Zeolites, Nano Catalysts, Nano-sensors.

UNIT V - GREEN PLASTICS MANUFACTURING (9 hours)

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

REFERENCES

1. David. T, Allen and David R. Shonnard, "*Green engineering*" Prentice Hall NJ, 2002.
2. David Dornfeld, "*Green manufacturing fundamental and application"* Prentice hall, 2002.
3. Sammy Shinga. G "*Green electronics design and manufacturing"* Prince publications, 2008.
4. James clark, "*Green chemistry"* Blackwell publishing, 2008.
5. Paulo Davim, "*Sustainable Manufacturing"* Wiley publications, 2010.
6. Frank Kreith, George Tchobanoglous, "*Solid waste management"* McGraw Hill, 2002.
7. Stevens. E. S "*Green plastics"* Princeton university press, 2002.
8. Robert Ayres. U "*A Handbook of Industrial Ecology"* Edward elgar publishing, 2002.

	ADVANCED CRYSTAL GROWTH TECHNIQUES	L	T	P	C
NT2108	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

The course brings together the science and technology of growing crystals, defect characterization and techniques, and understanding the defect formation including defects modeling

INSTRUCTIONAL OBJECTIVES

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

UNIT I - CRYSTAL GROWTH THEORY (9 hours)

Introduction – Nucleation – Gibbs – Thomson equation for melt and solution – kinetic theory of nucleation – Limitation of classical nucleation – Rate of nucleation – Different shapes of nucleus– spherical, cap shaped and cylindrical

UNIT II - GROWTH FROM MELT (9 hours)

Bridgeman method – Kyropolous method – Czochralski method – Verneuil method – Zone melting method.Growth from flux – Slow cooling method – Temperature difference method – High pressure method – Solvent evaporation method – Top seeded solution growth.

UNIT III - GROWTH FROM VAPOR PHASE (9 hours)

Physical vapor deposition – Chemical vapor transport – Open and Closed system – Thermodynamics of chemical vapor deposition process – Physical and Thermo-chemical factors affecting growth process.

UNIT IV - GROWTH FROM SOLUTIONS (9 hours)

Solvent and solutions – Solubility – Preparation of a solution – Saturation and supersaturation– Measurement of supersaturation – Expression for supersaturation – Low temperature growth solution growth – Slow cooling method – Manson jar method – Evaporation method – Temperature gradient method – Electro

crystallization.Growth from gels – Experimental methods – Chemical reaction method – Reduction method– Complex decomposition method – Solubility reduction method – Growth by hydrothermal method.

UNIT V - EPITAXY **(9 hours)**

Vapor phase epitaxy – Liquid phase epitaxy – Molecular beam epitaxy – Atomic layer epitaxy– Electro-epitaxy – Metalorganic vapor phase epitaxy – Chemical beam epitaxy.

REFERENCES

1. Sangwal. K, "*Elementary Crystal Growth*" 1st Ed., Saan Publisher, UK, 1994.
2. Faktor. M, and Garet. I, "*Growth of crystal from vapor*" 1st Ed., Chapmann and Hall, 1988.
3. Santhana Ragavan. P.and Ramasamy. P.,"*Crystal growth and process*", 1st Ed., KRU Publications, 2000.
4. Ramasamy. P., ISTE Summer School Lecture Notes, "*Crystal Growth Centre*", Anna University, Chennai, 1991.
5. Brice, J. C, "*Crystal growth process*", 1st Ed., John Wiley Publications, New York, 1986.
6. Chernov. A. A, "*Modern Crystallography: III – Crystal Growth*", 1st Ed., Springer series in Solid State, New York, 1984.

NT2109	CARBON NANOTUBE ELECTRONICS AND DEVICES	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

To provide the structural and electronic properties of carbon nanotubes, as well as the device structures and operation. It also deals with the incorporation of functionalized carbon nanotubes in field effect transistor, carbon nanotube device modeling and circuit simulation

INSTRUCTIONAL OBJECTIVES

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

UNIT I - BASICS OF CARBON NANOTUBES (9 hours)

Carbon materials – Allotropes of carbon – Structure of carbon nanotubes – Types of CNTs– Electronic properties of CNTs – Band structure of Graphene – Band structure of SWNT from graphene – Electron transport properties of SWNTs – Scattering in SWNTs – Carrier mobility in SWNTs.

UNIT II - SYNTHESIS AND INTEGRATION OF SWNT DEVICES (9 hours)

Introduction – CVD synthesis – Method – Direct incorporation with device fabrication process– SWNT synthesis on metal electrodes – Lowering the synthesis temperature – Controlling the SWNT growth – Location, Orientation, Chirality – Narrowing diameter distributions – Chirality distribution analysis for different CVD processes – Selective removal of the metallic nanotubes in FET devices – Integration.

UNIT III - CARBON NANOTUBE FIELD-EFFECT TRANSISTORS (9 hours)

Schottky barrier heights of metal S/D contacts – High k-gate dielectric integration – Quantum capacitance – Chemical doping – Hysteresis and device passivation – Near ideal, Metal-contaced MOSFETs – SWNT MOSFETs – SWNT band-to-band tunneling FETs.

UNIT IV - AC RESPONSE AND DEVICE SIMULATION OF SWNT FETS (9 hours)

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

UNIT V - CARBON NANOTUBE DEVICE MODELING AND CIRCUIT SIMULATION (9 hours)

Schottky barrier SWNT-FET modeling – Compact model for circuit simulation – Model of the intrinsic SWNT channel region – Full SWNT-FET model – Applications of the SWNT-FET compact model – Performance modeling for carbon nanotube interconnects – Circuit models for SWNTs– Circuit models for SWNT bundles – Circuit models for MWNTs – Carbon nanotube interconnects – Applications.

REFERENCES

1. Ali Javey and Jing Kong, "*Carbon Nanotube Electronics*" Springer Science media, 2009.
2. Michael. J, O'Connell, "*Carbon nanotubes: Properties and Applications*", CRC/Taylor & Francis, 2006.
3. Francois Leonard, "*The Physics of Carbon Nanotube Devices*", William Andrew Inc., 2009.
4. Saito. R and Drbselmus. M. S, "*Physical properties of Carbon Nanotubes*" Imperial College Press, 1998.

	NANOSCALE INTEGRATED COMPUTING	L	T	P	C
NT2110	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

Nanoscale integrated computing is an emerging technology with potential applications. The nanoscale architecture provides an increased computational speed, power-efficient, reduces the space requirements for interconnects and allows for fundamentally new computing paradigms

INSTRUCTIONAL OBJECTIVES

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

UNIT I - AN INTRODUCTION TO NANOCOMPUTING (9 hours)

Micro computing era – Transistor as a switch, difficulties with transistors at the nanometer scale– Nanoscale devices – Molecular devices – Nanotubes – Quantum dots – Wave computing – Quantum computing

UNIT II - QUANTUM COMPUTING (9 hours)

Reversible computations – Quantum computing models – Complexity bounds for quantum computing – Quantum compression – Quantum error correcting codes – Quantum cryptography– Computing with quantum dot cellular automata – Quantum dot cellular automata cell – Ground state computing – Clocking – QCA addition – QCA multiplication – QCA memory – 4-bit processor

UNIT III - SPIN-WAVE ARCHITECTURES (9 hours)

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

UNIT IV -MOLECULAR COMPUTING (9 hours)

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

UNIT V -COMPUTATIONAL TASKS IN MEDICAL NANOROBOTICS (9 hours)

Medical Nanorobot designs – Microbivores – Clottocytes – Chromallocytes – Common functions requiring onboard computation – Nanorobot control protocols: Operation protocols– Biocompatibility protocols – Theater protocols – Nanoscale image processing: Labeling problem– Convex Hull problem – Nearest neighbor problem

REFERENCES

1. Nielsen. M. A, and Isaac Chuang. L, "*Quantum computation and quantum information*", Cambridge University Press, 2000.
2. Jain. A. K, "*Fundamentals of Digital Image Processing*", Prentice-Hall,1988.
3. Schroder .D. K, "*Semiconductor Material and Device Characterization*", New York, 2006.
4. Zhou. C and New Haven, "*Atomic and Molecular wires*", Yale University Press, 1999.

	MICRO / NANO DEVICES AND SENSORS	L	T	P	C
NT2111	Total Contact Hours - 45	**3**	**0**	**0**	**3**
	Prerequisite				
	Nil				

PURPOSE

To have deeper understanding in fabrication of micro/nano devices and their architectures of sensing applications.

INSTRUCTIONAL OBJECTIVES

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

UNIT I - INTRODUCTION (9 hours)

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

UNIT II - MODELING OF MICRO AND NANO SCALE ELECTROMECHANICAL SYSTEMS (9 hours)

Introduction to modeling, analysis and simulation, basic electro-magnetic with application to MEMS and NEMS, modeling developments of micro-and nano actuators using electromagnetic-Lumped-parameter mathematical models of MEMS, energy conversion in NEMS and MEMS.

UNIT III - INORGANIC AND ORGANIC ENABLED SENSORS (9 hours)

Introduction-types of sensors-Mechanical, optical, spintronic, bioelectronic and biomagnetic sensors-surface modification-surface materials and interactions and its examples

UNIT IV - SENSOR CHARACTERISTICS AND PHYSICAL FFECTS (9 hours)

Introduction to sensors, static Characteristics and dynamic characteristics, Physical effects : - Photoelectric Effect, Photoluminescence Effect, Electroluminescence Effect, Chemiluminescence Effect, Doppler Effect , Hall Effect, thermoelectric effect, magneto-optical phenomena

UNIT V - FUTURE NANOSYSTEMS (9 hours)

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

REFERENCES

1. Sergey Edward Lyshevski, Lyshevski Edward Lyshevski, "*Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano-and Micro-Engineering* "– 2nd Ed., CRC Press, 2005.
2. Edelstein. A. S, and Cammarata, "*Nanomaterials: Synthesis, Properties and Applications Institute of Physics"*, Bristol, Philadelphia: Institute of Physics, 2002.
3. Mahalik. N. P, "*Micro manufacturing and Nanotechnology",* Springer Berlin Heidelberg New York 2006.
4. Mark. J Jackson, "*Micro and Nanomanufacturing"*, 2007.
5. Zheng Cui, "*Nanofabrication, Principles, Capabilities and Limits"*, 2008.
6. Kalantar–Zadeh. K, "*Nanotechnology Enabled Sensors*, Springer," 2008.
7. Serge Luryi, Jimmy Xu, Alex Zaslavsky, "*Future trends in MicroElectronics",* John Wiley & Sons, Inc. Hoboken, New Jersey 2007.

NT2112	**SPECTROSCOPIC TECHNIQUES FOR NANOMATERIALS**	**L**	**T**	**P**	**C**
	Total Contact Hours - 45	**3**	**0**	**0**	**3**
	Prerequisite				
	Nil				

PURPOSE

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

INSTRUCTIONAL OBJECTIVES

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

UNIT I - NANO OPTICS (9 hours)

Basic Concepts-Spontaneous Emission- Classical Bound- Radiating Electron-Quantum Mechanical Radiative Decay-Absorption and Emission - Absorption Coefficient and Absorption Cross-Section,Absorption and Induced Emission-Nano-optics and local spectroscopy -Scanning plasmon near-field optical spectroscopy (SPNM)-near-field optical spectroscopy- nearfield nonlinear optics.

UNITII -MOLECULAR SPECTROSCOPIES OF NANOASSEMBLIES (9 hours)

Simplified model for vibrational interactions-Characteristic bands for organic compounds - Attenuated-total reflection (ATR) and grazing incidence angle techniques-Reflection-absorption IR spectroscopy (RAIRS)-The Raman Effect-Lateral and in-depth Resolution of Conventional μRS- Resonant Raman Spectroscopy (RRS) - Nano-specific Modes- Surface-Enhanced Raman Spectroscopy (SERS)- Nano-Raman- Phase Identification and Phase Transitions in Nanoparticles- Characterizing Carbon Materials with Raman Spectroscopy.

UNIT III - NONLINEAR SPECTROSCOPIES (9 hours)

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

UNIT IV - LUMINESCENCE SPECTROSCOPY (9 hours)

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

UNIT V - ELECTRON SPECTROSCOPIES FOR NANOMATERIALS (9 hours)

X-Ray Beam Effects,Spectral Analysis -Core Level Splitting Line widths- Elemental Analysis: Qualitative and Quantitative -Secondary Structure ,XPS Imaging -Angle-Resolved - Basic Principles of AES-Instrumentation- Experimental Procedures Including Sample Preparation - AES Modifications and Combinations with other Techniques -Auger Spectra: Direct and Derivative Forms and Applications-Electron energy loss spectroscopy of nanomaterials.

REFERENCES

1. Vladimir. G, Bordo and Horst-Günter Rubahn; "*Optics and Spectroscopy at Surfaces and Interfaces"* John-Wiley and Sons, Inc., 2005.
2. William. W, Parson, "*Modern Optical Spectroscopy"*, Springer, 2007.
3. Collin Banwell, Mc Cash, "*Fundamentals of Molecular Spectroscopy"*, McGraw Hill 1994.
4. Harvey Elliot White, "*Introduction to Atomic Spectra"*, McGraw Hill, 1934.
5. Francis Rouessac and Annick Rouessac, "*Chemical Analysis-Modern Instrumentation Methods and Techniques"*,2000.
6. Joseph. R, Lakowicz "*Principles of fluorescence spectroscopy"*, Springer, 2010.
7. Pavia, Lampman, Kriz, Vyvyan, "*Introduction to spectroscopy"*, Cengage learning, 2009.
8. Jin Jhong Jhang, "*Optical properties and spectroscopies of Nanomaterials"*, World Scientific Publishing 2009 .

	CHEMISTRY OF NANOMATERIALS	L	T	P	C
NT2113	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

To provide an adequate knowledge on various nanochemistry aspects.

INSTRUCTIONAL OBJECTIVES

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

UNIT I - SIZE EFFECTS ON STRUCTURE AND MORPHOLOGY OF NANOPARTICLES (9 hours)

Fundamental Properties - Size Effects on Structure and Morphology of Free or Supported Nanoparticles - Size and Confinement Effects - Fraction of Surface Atoms - Specific Surface Energy and Surface Stress - Effect on the Lattice Parameter - Effect on the Phonon Density of States- Nanoparticle Morphology - Equilibrium Shape of a Macroscopic Crystal - Equilibrium Shape of Nanometric Crystals - Morphology of Supported Particles.

UNIT II - SUPERPLASITICITY AND REACTIVITY OF METAL NANOPARTICLE (9 hours)

Superplasticity – Introduction – Mechanism - Superplastic Nanostructured Materials - Industrial Applications .Reactivity of Metal Nanoparticles - Size Effects-Structural Properties - Electronic Properties - Reactivity in Chemisorption and Catalysis of Monometallic Nanoparticles - Support Effects - Alloying Effects - Effect of Surface Segregation - Geometric Effects -Electronic Effects- Preparation and Implementation in the Laboratory and in Industry.

UNIT III - SUPRAMOLECULAR CHEMISTRY (9 hours)

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

UNIT IV - SUPERCRITICAL FLUIDS **(9 hours)**

Supercritical Fluids –Introduction – Physicochemical Properties - Solubility - Viscosity - Diffusion -Thermal Conductivity - Applications - Purification and Extraction - Synthesis.

UNIT V - FEATURES OF NANOSCALE GROWTH **(9 hours)**

Specific Features of Nanoscale Growth – Introduction - Thermodynamics of Phase Transitions-Dynamics of Phase Transitions - Thermodynamics of Spinodal Decomposition - Thermodynamics of Nucleation – Growth - Size Control - Triggering the Phase Transition- Application to Solid Nanoparticles - Controlling Nucleation - Controlling Growth - Controlling Aggregation. Stability of Colloidal Dispersions - Breaking Matter into Pieces.

REFERENCES

1. Brechignac. C Houdy. P. Lahmani. M, "*Nanomaterials and Nanochemistry*", Springer publication 2007.
2. Kenneth. J, Klabunde, "*Nanscale materials in chemistry*", Wiley Interscience Publications 2001.
3. Rao. C. N Muller. A, Cheetham. A. K ,"*Nanomaterials chemistry*", Wiley-VCH 2007.

NT2114	THIN FILM SCIENCE AND TECHNOLOGY	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

This course is intended for the students to teach important techniques, principles and underlying phenomena associated with thin film technology

INSTRUCTIONAL OBJECTIVES

1.	To teach scientific principles behind thin film technology.
2.	To familiarize them with the principles, equipment, use, and limitations of different deposition techniques
3.	To give students an overview of the phenomena and concepts involved in thin film

UNIT I - THIN FILM DEPOSITION TECHNIQUES (9 hours)

Introduction – Kinetic theory of gases - Physical vapour deposition techniques – Physics and Chemistry of Evaporation - Thermal evaporation – Pulsed laser deposition – Molecular beam epitaxy –Sputtering deposition – DC, RF, Magnetron, Ion beam and reactive sputtering - Chemical methods –Thermal CVD – Plasma enhanced CVD – Spray Pyrolysis – Sol Gel method – Spin and Dip coating –Electro plating and Electroless plating – Deposition mechanisms

UNIT II - CHARACTERIZATION TECHNIQUES (9 hours)

Surface analysis techniques – Auger Electron spectroscopy – Photoelectron Spectroscopy– Secondary Ion Mass Spectroscopy – X-ray Energy Dispersive Analysis – Rutherford Backscattering spectroscopy - Imaging Analysis Techniques – Scanning Electron Microscopy – Transmission Electron Microscopy – Optical analysis Techniques – Ellipsometry – Fourier Transform Infrared Spectroscopy – Photoluminescence Spectroscopy

UNIT III - ADSORPTION AND DIFFUSION IN THIN FILMS (9 hours)

Physisorption – Chemisorption – Work function changes induced by adsorbates – Two dimensional phase transititions in adsorbate layers – Adsorption kinetics – Desorption techniques. Fundamentals of diffusion –Grain Boundary Diffusion – Thin Film Diffusion Couples - Inter Diffusion-Electromigration in thin films – Diffusion during film growth

UNIT IV - STRESS IN THIN FILMS (9 hours)

Origin of Thin film stress - Classifications of stress – Stress in epitaxial films – Growth Stress in polycrystalline films – Correlation between film stress and grain structure – Mechanisms of stress evolution – film stress and substrate curvature – Stoney formula – Methods of curvature measurement – Scanning laser method.

UNIT V - MODIFICATION OF SURFACES AND FILMS (9 hours)

Introduction – Laser and their Interactions with Surfaces – Laser modification effects and applications – Laser sources and Laser scanning methods - Thermal analysis of Laser annealing- Laser surface alloying - Ion implantation effects in solids – Energy loss and structural modification– compositional modification - Ion beam modification phenomena and applications

REFERENCES

1. Amy. E, Wendt, "*Thin Films - High density Plasmas"*, Volume 27, Springer Publishers. 2006.
2. Rointan. F, Bunshah," *Hand Book of Deposition technologies for Thin Films and coatings by Science, Technology and Applications"* ,Second Edition , Noyes Publications, 1993.
3. Milton Ohring, "*Materials Science of Thin films"* Published by Academic Press Limited 1991.
4. Freund. L.B and S.Suresh, "*Thin Film Materias"*, 2003.
5. Hans Luth, "*Solid surfaces, Interfaces and Thin Films"'* 4th edition, Springer Publishers 2010.
6. Harald Ibach, "*Physics of Surfaces and Interfaces",* Springer Publishers 2006.

	MICRO/NANO COLLOIDS AND EMULSIONS	L	T	P	C
NT2115	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

Emulsions are used in industry as components in a huge range of formulated products or as effect chemicals in the production or processing of other materials.

INSTRUCTIONAL OBJECTIVES

1.	To define and identify emulsions and emulsifying agents
2.	To understand the mechanism of emulsions and the process of stabilization
3.	To provide basic knowledge on formulation and characterization of emulsions

UNIT I – INTRODUCTION (9 hours)

Definition of nano- and micro- emulsions – Reason for their long term kinetic stability – Practical application in personal care products and cosmetics, healthcare products, pharmaceuticals and agrochemicals – Schematic representation of oil/water and water/oil emulsions – Comparison with micelles and macroemulsions – Methods of emulsification: Pipe flow, static mixers and general stirrers, high-speed mixers, colloid mills and high pressure homogenizers – continuous and batch-wise preparations – turbulent flow.

UNIT II - MECHANISM OF EMULSIFICATION (9 hours)

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

UNIT III - FORMULATION OF EMULSION (9 hours)

High pressure homogenization and efficiency of preparation – The Phase Inversion Temperature (PIT) principle – Variation of interfacial tension with temperature – Phase diagrams as a function of temperature – Formulation of microemulsions – Selection of microemulsions: Hydrophilic Lipophilic Balance (HLB) concept – Phase Inversion Temperature (PIT) concept – Cohesive Energy Ratio (CER) concept.

UNIT IV - CHARACTERIZATION OF EMULSIONS (9 hours)

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

UNIT V - STABILITY OF EMULSION (9 hours)

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

REFERENCES

1. Seid Mahdi Jafari, "*Encapsulation of nano-emulsions by spray drying*", Lambert Academic Publishing, 2009.
2. Hans Lautenshlager "*Emulsions*", Kosmetik International, 2002.
3. Roque Hidalgo-Alvarez, "*Structure and Functional properties of Colloids*", CRC Press, 2009.
4. Richard. J, Fann, "*Chemistry and Technology of Surfactants*", Wiley-Blackwell, 2006.

	NANOTECHNOLOGY BUSINESS APPLICATIONS AND COMMERCIALIZATION	L	T	P	C
NT2116	Total Contact Hours – 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

The course outlines the nano-related business and enables the students how to link scientific knowledge to the business.

INSTRUCTIONAL OBJECTIVES

1.	Develop qualitative and quantitative understanding to the relevant concepts of nanoscale systems, and revive the responsibilities of distributed economy of such systems
2.	To provide a overview knowledge of economics involved in nanotechnology based commercialization, and to induce thinking in the direction of nanotechnology based business market
3.	To address the overall benefits of systems costs, effective strategies, and promote the growth of the learners using various models and detailed analyses

UNIT I – OVERVIEW **(9 hours)**

Introduction **–** types of nanobusinesses **–** ease of entry **–** intellectual property **–** ethics**–** risks/dangers **–**standardization, investors and commercialization centers **–** business applications **–** social aspects of nanotechnology

UNIT II - MARKET LANDSCAPE **(9 hours)**

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

UNIT III - COMMERCE AND REGULATION **(9 hours)**

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

UNIT IV - BUSINESS STRUCTURES (9 hours)

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

UNIT V - MATERIALS PROCESSING ECONOMICS (9 hours)

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

REFERENCES

1. Sherron Sparks, "*Nanotechnology: Business Applications and Commercialization*," CRC Press, Taylor & Francis group, London 2012.
2. Jeffrey. H, Matsuura" *Nanotechnology Regulation and Policy Worldwide"*, Artech House; 1 Ed., 2006.
3. *"Nanotechnology developments in India – A status repor"t*, The Energy and Resources Institute (TERI), India 2009.
4. *"Nanotechnology: a Realistic Market Assessment"*, Research, Market Forecasting 2006.
5. Michael. T, Burke, "*Nanotechnology: The Business, Perspectives in Nanotechnology"*, CRC Press, Colorado, USA 2008.

	NANOTECHNOLOGY INTELLECTUAL PROPERTY RIGHTS AND INNOVATION	L	T	P	C
NT2117	Total Contact Hours - 45	**3**	**0**	**0**	**3**
	Prerequisite				
	Nil				

PURPOSE

To overview the caveats concerning laws and its practices, and other governing principles related to the technological development and its protected principles

INSTRUCTIONAL OBJECTIVES

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

UNIT I - BACKGROUND (9 hours)

Introduction: the invisible infrastructure of innovation-Intellectual Property Dynamics in Society- The types of Intellectual Property- Patent documents-the construction of the patent, face of the patent, conception, body of the patents - The innovation cycle- The rise of the intellectual property system-Balancing the tension between exclusive rights and the accessible domains

UNIT II - BASICS OF MANAGING INTELLECTUAL PROPERTY IN ORGANIZATIONS (9 hours)

The innovation forest: intellectual property rights and how they grow- The ABCDs of intellectual property: flow and infringement of IP rights-the patent system - copyrights-trademarks-trade secrets- The global diversity of innovation communities-The role of the innovation chief.

UNIT III - NANOTECHNOLOGY POLICY AND REGULATION (9 hours)

Understanding Nanotechnology- the industrial structure giving rise to Nanotechnology- Societal and Ethical Implications-Environmental Regulation - National Security and Export Controls- Federal Funding-Conclusions

UNIT IV - THE ECONOMIC AND LEGAL FOUNDATIONS (9 hours)

A Brief Digression into Terminology - Understanding Open Source - Credit Unions - Open Source: An Analogy - The Role of Open Source Licenses - Different Types of Open Source Licenses- Law and Code - Intellectual Property and Market Failure - Evaluating the System

UNIT V - STRATEGIC MANAGEMENT OF INTELLECTUAL PROPERTY (9 hours)

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

REFERENCES

1. Michael Golin, "*Driving Innovation-Intellectual Property strategies for a dynamic world",* Venable LLP, Washington DC, 2008.
2. Van Lindberg, "*Intellectual Property and Open Source:-A Practical guide to Protecting code"* O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, 2008.
3. John. C, Miller, Ruben Serrato, "*The Handbook of Nanotechnology, Business, Policy, and Intellectual Property Law",* John Wiley & Sons, Inc., New Jersey, 2005.
4. Attorney Richard Stim, "*Patents, Copyrights, Trademarks- An Intellectual Property desk Reference",* Berkeley, 2006.

NT 2118	**NANO – CMOS CIRCUIT AND PHYSICAL DESIGN**	**L**	**T**	**P**	**C**
	Total Contact Hours - 45	**3**	**0**	**0**	**3**
	Prerequisite				
	Nil				

PURPOSE

To introduce the students the basic principles of Nano-CMOS Circuit and Physical Design

INSTRUCTIONAL OBJECTIVES

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

UNIT I - NANO-CMOS SCALING PROBLEMS AND IMPLICATIONS (9 hours)

Design Methodology in the Nano-CMOS Era – Scaling – Overview of Sub-100-nm Scaling Challenges and Subwavelength Optical Lithography – Back-End-of-Line Challenges (Metallization) – Front-End-of-Line Challenges (Transistors) – Process Control and Reliability Lithographic Issues and Mask Data Explosion – New Breed of Circuit and Physical Design – Modeling Challenges– Need for Design Methodology Changes

UNIT II - PRACTICALITIES OF SUBWAVELENGTH OPTICAL LITHOGRAPHY (9 hours)

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

UNIT III - PROCESS SCALING IMPACT ON DESIGN MIXED-SIGNAL CIRCUIT DESIGN (9 hours)

Design Considerations – Device Modeling – Passive Components – Design Methodology– Benchmark Circuits – Design Using Thin Oxide Devices – Design Using Thick Oxide Devices– Low-Voltage Techniques – Current Mirrors – Input Stages – Output Stages – Bandgap References– Design Procedures – Electrostatic Discharge Protection – Multiple-Supply Concerns – Noise Isolation – Guard Ring Structures – Isolated NMOS Devices – Epitaxial Material versus Bulk Silicon – Decoupling – Power Busing – Integration Problems – Corner Regions – Neighboring Circuitry

UNIT IV - ELECTROSTATIC DISCHARGE PROTECTION DESIGN (9 hours)

ESD Standards and Models – ESD Protection Design – ESD Protection Scheme – Turn-on Uniformity of ESD Protection Devices – ESD Implantation and Silicide Blocking – ESD Protection Guidelines – Low-C ESD Protection Design for High-Speed I/O – ESD Protection for High-Speed I/O or Analog Pins – Low-C ESD Protection Design – Input Capacitance Calculations – ESD Robustness – Turn-on Verification – ESD Protection Design for Mixed-Voltage I/O – Mixed-Voltage I/O Interfaces – ESD Concerns for Mixed-Voltage I/O Interfaces – ESD Protection Device for a Mixed-Voltage I/O Interface – ESD Protection Circuit Design for a Mixed-VoltageI/O Interface – ESD Robustness – Turn-on Verification – SCR Devices for ESD Protection – Turn-on Mechanism of SCR Devices – SCR-Based Devices for CMOS On-Chip ESD Protection

UNIT V - SIGNAL INTEGRITY PROBLEMS IN ON-CHIP INTERCONNECT(9 hours)

Interconnect Figures of Merit – Interconnect Parasitics Extraction – Circuit Representation of Interconnects – RC Extraction – Inductance Extraction – Signal Integrity Analysis – Interconnect Driver Models – RC Interconnect Analysis – RLC Interconnect Analysis – Noise-Aware Timing Analysis – Design Solutions for Signal Integrity – Physical Design Techniques – Circuit Techniques

REFERENCES

1. Ban. P, Wong, Anurag Mittal, Yu CaoGreg Starr, "*Nano-CMOS Circuit and physical design*", John Wiley & Sons, Inc.Hoboken, New Jersey,2000.
2. Charles chiang, Jamil Kawa, "*Design for manufacturability and yield for Nano - Scale CMOS*", Springer, 2007.

NT2119	SOLID STATE TECHNOLOGY	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

The course aims at providing an overview of basic physics of solids and advanced topics in solid state materials of technological value.

INSTRUCTIONAL OBJECTIVES

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

UNIT I - CRYSTAL BINDING AND ELASTIC CONSTANTS (9 hours)

Crystals of Inert gases – van der Waal-London interaction – Cohesive Energy - Ionic crystals– Madelung Energy - Covalent crystals – Metals – Hydrogen bonded solids – Analysis of Elastic strains – Dilation and Stress components - Elastic Compliance and Stiffness constants – Evaluation of Bulk Modulus and Compressibility - Elastic Waves in Cubic Crystals

UNIT II - PHONON DYNAMICS AND THERMAL PROPERTIES (9 hours)

Overview of Reciprocal lattice, Brillouin zone – Crystals with monoatomic basis – Two atoms per primitive basis – Quantization of Elastic waves – Phonon momentum – Elastic properties – Phonon Heat Capacity – Planck distribution – Density of states – Debye T^3 law – Einstein's model of Density of states - Thermal expansion – Heat conduction by Phonons – Vibrational and Thermal properties of Nanostructures

UNIT III - ELECTRONIC PROPERTIES OF SOLIDS AND NANOSTRUCTURES (9 hours)

Overview of Band theory, Bloch's theorem – Boundary conditions (counting states) – Types of solids : Band picture – Cohesion – Rigid band model and Density of States – Fermi statistics of electrons – Statistics of carriers in Semiconductor – Electronic specific heat - Imaging techniques for Nanostructures – Electronic structure of 0D and 1D systems – Electrical transport in 0D, 1D

UNIT IV - ELECTRONIC TRANSPORT PHENOMENA AND OPTICAL PROCESSES (9 hours)

Boltzmann equation – Electrical conductivity – Calculation of relaxation time – Impurity scattering– Ideal resistance – Carrier mobility – General transport coefficients – Thermal conductivity– Thermo-electric effects – Wiedmann-Franz Law - Magneto-resistance - Optical reflectance – Excitons– Raman Effects in Crystals - Energy Loss of Fast particles in Solid

UNIT V - SEMICONDUCTOR TECHNOLOGY (9 hours)

Holes, Equations of motion, Effective mass – Silicon and Germanium – Intrinsic carrier concentration and Intrinsic conductivity – Impurity conductivity – Donor and Acceptor states– Semi-metals – Superlattices – Bloch oscillator - Zener tunneling - p-n Junction diode – V-I Characterstics- Bipolar Transistors – Circuit arrangements – Junction Field-Effect transistor –Metal-Semiconductor Junctions – Schottky Barrier Diode – Rectifying Metal-N/P semiconductor junction – MOSFET and MESFET

REFERENCES

1. Kittel. C "*Introduction to Solid State Physics",* Wiley India Pvt. Ltd., 2007.
2. Ziman. J. M "*Principles of the Theory of Solids",* Cambridge University Press, 2011.
3. Ashcroft. N. W. Mermin. N. D "*Solid State Physics",* Brooks/Cole Publishers, 2003.
4. Ibach. H, Harald Luth, "*Solid-State Physics: An Introduction to Principles of Materials Science",* Springer, 2003.

NT2120	CELL AND MOLECULAR BIOLOGY	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

The course is to understand the basic concept of cell biology & To understand the cell organization and cell cycle, Acquire the knowledge of various signaling mechanisms

INSTRUCTIONAL OBJECTIVES

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

UNIT I - INTRODUCTION TO CELL BIOLOGY (9 hours)

Cell theory- origin and evolution of cells. Tools of cell biology-Light microscopy-Electron Microscopy-Subcelluar fractionation, study of the living cells-Fixation and staining: - freeze drying and free substitution. Microtomes & embedding- Chemical basis of staining metachromatia, cytochemical methods.

UNIT II - ORGANIZATION AND CELL CYCLE (9 hours)

Organization of cellular structures- prokaryotes & eukaryotes: Molecular composition of cells- Carbohydrates- Lipids- Nucleic acids- Proteins, Cell membranes-Membrane lipids. Cell wall and extra cellular matrix- cytoskeleton- cell membrane (including plasma membrane)- Endocytosis- Cell-cell interactions. Cell cycle- Mitosis-Meiosis-Regulation of cell cycle- Molecular basis.

UNIT III - DNA STRUCTURE, AMINO ACIDS & PROTIENS (9 hours)

Components of dna - purine bases -pyrimidine bases deoxyribose sugar - physical and chemical properties of dna - chemical modifications - introduction of dna nanotechnology- primary, secondary, super secondary, tertiary, quaternary structures - the methods to determine - prediction methods -utilization of genomic databases. Structure and reactions of amino acids - hydrophilic and hydrophobic amino acids -

table of standard amino acid abbreviations and side chain properties- nonstandard amino acids- biochemistry of proteins - cellular functions of proteins - introduction to protein based nanotechnology.

UNIT IV - ORGANELLES & MEMBRANE (9 hours)

Cell organelles-Mitochondria-Plastids-Endoplasmic reticulum- Ribosomes-Endosomes- Golgi- Lysosomes-Peroxysomes-Hydrogenosomes & centrosomes. The cell nucleus: Nuclear envelope- Nucleolus- Chromosomes. Prokaryotic nucleoids(bacterial & plastid genomes).Membrane functions; Cell adhesions & cell junctions. Membrane transport- Neurotransmission- Vesicular transport & membrane function(Secretory & endocytic pathways). Membrane proteins-Transport across the membranes.

UNIT V - SIGNALING & IMMUNOTECHNOLOGY (9 hours)

Cell signaling & cell transduction:- Signalling molecules & their receptors- Functions of cell surface receptors- Pathways of intracellular signal transduction. Signal transduction and cytoskeleton- Development & differentiation- Regulation of programmed cell death. Innate immunity- adaptive immunity- cells of reticulo endothelial system- antigen presenting cells and its pathways- complement system and its pathways- tumor immunology- life cycle of HIV Virus- monoclonal antibodies synthesis and applications

REFERENCES

1. Geoffrey. M, Copper, "*The Cell A Molecular Approach*"; 2nd Edition, ASM press, Sinauer Associates, Inc.,Washington, 2000.
2. Harvey Lodish: Arnold Berk: Zipursky:Paul. S.L, Matsudaira: David Baltimore and James Danell, "*Molecular Cell Biology*"; 4th Ed., W.H Freeman and company, 2000.
3. De Robertis. E.D.P and De Robertis. E.M.F, "*Cell and Molecular Biology*". 8th Ed., Lippincott Williams and Wilkins, 2001.
4. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter, "*Molecular Biology Of The Cell",* New York: Garland Science, 2002.
5. Janis Kuby Freeman. W H, "*Immunology*" 2006.

NT2121	NANOLITHOGRAPHY AND DEVICE FABRICATION	L	T	P	C
	Total Contact Hours – 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

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

INSTRUCTIONAL OBJECTIVES

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

UNIT I - THE SCIENCE OF MINIATURIZATION (9 hours)

Moore's Laws (1,2,&3) and technology' Roadmap–clean rooms - Processing Methods: - Cleaning– Oxidation – Lithography – Etching- – CVD - Diffusion – Ion implantation – metallization – state of the art CMOS architectures Photolithography Overview – Critical Dimension – Overall Resolution– Line-Width – Lithographic Sensitivity and Intrinsic Resist Sensitivity (Photochemical *Quantum Efficiency*) – Resist Profiles – Contrast and Experimental Determination of Lithographic Sensitivity – Resolution in Photolithography – Photolithography Resolution Enhancement Technology

UNIT II - NANOSTRUCTURING BY PHYSICAL TECHNIQUES (9 hours)

Next-Generation Technologies: – State-Of-The-Art (*including principles, capabilities, limits, applications*) EUV lithography – Phase-shifting photolithography – X-ray lithography – Electron Beam Direct Writing System – Focused ion beam (FIB) lithography – Neutral atomic beam lithography – Plasma-Aided Nanofabrication – Soft Lithography – Nanosphere Lithography– Nanoimprint – Dip-pen nanolithography – key consequences of adopted techniques

UNIT III - NANOMANIPULATION AND PROCESSING (9 hours)

Conventional techniques: Scanning tunneling microscopy (STM) – Atomic force microscopy (AFM) – Near-field scanning optical microscopy (NSOM) – **Advanced**

Techniques: Embossing and surface passivation, Dimensional Subtraction and Addition, Multistep Processing, of -Microcontact printing– Molding – implications and applications of the conventional and advanced techniques

UNIT IV - NANOMETER DEVICES (9 hours)

Material Wave Nanotechnology: Nanofabrication Using a de Broglie Wave-Electron Beam Holography – Atomic Beam Holography- Nanometer Lithography Using Organic Positive/Negative Resists – Sub-10 nm Lithography Using Inorganic Resist – 40 nm-Gate-Length Metal-Oxide-Semiconductor Field-Emitter-Transistors-14 nm Gate-Length Electrically Variable Shallow Junction MOSFETs-Operation of Aluminum-Based Single-Electron Transistors at 100 Kelvins- Room Temperature Operation of a Silicon Single-Electron Transistor

UNIT V - SUB-LITHOGRAPHIC ARCHITECTURES (9 hours)

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

REFERENCES

1. Guozhong Cao, **"***Nanostructures & Nanomaterials Synthesis, Properties Applications"*, World Scientific Publishing Private Ltd., 2004.
2. W.R.Fahrner, "*Nanotechnology and Nanoelectronics – Materials, Devices, Measurement Techniques",* Springer-Verlag Berlin, 2006.
3. . Hannink. R. H. J and Hill. A. J, "*Nanostructure control of materials"*, CRC Press, 2006.
4. Zheng Cui, "*Nanofabrication, Principles, Capabilities and Limits"*, Springer Science business media, 2008.
5. Hari Singh Nalwa, "*Handbook of Nanostructured Materials and Nanotechnology* -Vol. 3- *Electrical Properties",* Academic Press, 2000.
6. Huff, Howard, "*Into The Nano Era: Moore's Law Beyond Planar Silicon CMOS"*, Springer-Verlag Berlin, 2009.
7. Marc. J, Madou, "*Fundamentals of Microfabrication: The Science of Miniaturization"*, CRC Press, 2002.
8. Kostya (Ken) Ostrikov and Shuyan Xu*, "Plasma-Aided Nanofabrication: From Plasma Sources to Nanoassembly",* WILEY-VCH, 2007.

NT2122	STATISTICAL THERMODYNAMICS FOR NANOSYSTEMS	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

To introduce to the students the basic principles of statistical thermodynamic principles for nanosystems and to lay emphasis on the fundamentals

INSTRUCTIONAL OBJECTIVES

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

UNIT I - THERMODYNAMICS OF SMALL SYSTEMS (9 hours)

Non-intensivity and Nonextensivity of Nanosystems -The Gibbs Equation for Nanosystems-Statistical Mechanics and Thermodynamic Property Predictions – Standard polymorphs-formalisms of controlled nucleation and growth of nanocystallites from a vitreous state-thermodynamics of polymorphic transformations in non-porous and nanoporous solids.

UNITII - NANOTHERMODYNAMICS (9 hours)

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

UNIT III - NON-EQUILIBRIUM THERMODYNAMICS (9 hours)

Thermostated Dynamical Systems - The Transient Fluctuation Theorem Thermodynamic Interpretation of the Dissipation Function - The Dissipation Theorem-NonequilibriumWork Relations- NonequilibriumWork Relations for Thermal Processes - Corollaries of the Fluctuation Theorem and NonequilibriumWork Relations - Generalized Fluctuation Theorem - Integrated Fluctuation Theorem -Second Law Inequality - Nonequilibrium Partition Identity - The Steady State Fluctuation Theorem-Minimum Average Work Principle .

UNIT IV - NONEQUILIBRIUM NANOSYSTEMS (9 hours)

Basics-Nanosystems Driven by Time-Dependent Forces-Jarzynski's Nonequilibrium Work Theorem- Mechanical Nanosystems- Friction in Double-Walled CarbonNanotubes-Electromagnetic Heating of Microplasmas-Mechanochemical Nanosystems-F1-ATPase Motor-Continuous state description-Discrete state description- Chemical Nanosystems- Chemical Transistor- Chemical Clocks in Field Emission Microscopy-DNA replication.

UNIT V - THERMODYNAMICS OF BIOLOGICAL SYSTEMS (9 hours)

Crystal-melt interfacial energies and solubilites for nanosized systems- Via the Ostwald-Freundlich equation, the size-selective growth process of nanoparticles-Bulk memberane partition- Nanothermodynamics of a Single Molecule- The Concept of Pseudoequilibrium- Cellular and Subcellular Systems.

REFERENCES

1. Ragone. D. V "*Thermodynamics of Materials"*, John Wiley & Sons, 1994.
2. David. R, Gaskell, "*Introduction to the Thermodynamics of Materials"*, Taylor & Francis, 2002.
3. Michael Rieth and Wolfram Schommers, *"Handbook of Theoretical and Computational Nanotechnology"*, American Scientific Publishers, 2005.
4. Lupis. C. H. P, "*Chemical Thermodynamics of Materials"*, Prantice Hall, 2000.
5. Christian. J. W,"*Theory of Phase Transformations in Metals and Alloys*", Pergamon Press, 2001.
6. Günter Radons, Benno Rumpf and Heinz Georg Schuster, **"***Nonlinear Dynamics of Nanosystems",* Wiley publishers, 2010.

	QUANTUM MECHANICS FOR NANOTECHNOLOGY	L	T	P	C
NT2123	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

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

INSTRUCTIONAL OBJECTIVES

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

UNIT I - THE SCHRODINGER'S EQUATION AND ITS MATHEMATICAL IMPLICATION (9 hours)

Development of Time Dependent Schrodinger's equation - Statistical interpretation of wave function - Normalization of wave function – Conservation of total probability, Dynamical variables and Hermitian operators - position, linear and angular momentum operators – Commutation relations- Ehrenfest theorem - Heisenberg uncertainty principle, Time Independent Schrodinger equation– Properties of energy eigen functions, Expansion postulate.

UNIT II - BOUND STATES & QUANTUM TUNNELING (9 hours)

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

UNIT III - QUANTUM DYNAMICS (9 hours)

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

UNIT IV - IDENTICAL PARTICLES AND SCATTERING THEORY (9 hours)

System of Identical particles – Symmetrization of wave functions - Exchange interactions - Free electrons in a metal – Fermi gas - Mutual scattering of two particles – Separation of Schrodinger equation in laboratory and center of mass frames - Quantum theory of Scattering – Differential and total cross sections, Scattering amplitude – Derivation using Green's functions - Born approximation - Scattering by spherically symmetric potentials.

UNIT V - QUANTUM COMPUTATION (9 hours)

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

REFERENCES

1. Bransden. B.H, and Joachain. C.J "*Quantum Mechanics"*, Pearson, 2007.
2. David. J, Griffiths, "*Introduction to Quantum Mechanics"*, Pearson, 2009.
3. Richard. L, Liboff, "*Introductory Quantum Mechanics"*, Pearson, 2003.
4. Mark Lundstrom, "*Fundamentals of Carrier Transport"*, Cambridge University Press, 2000.
5. Yoav Peleg, Reuven Pnini, Elyahu Zaarur, and Eugene Hecht, "*Schaum's Outline of Quantum Mechanics"*, Tata McGraw Hill, 2010.
6. Eugen Merzbacher, "*Quantum Mechanics"*, John Wiley & Sons, 1999.
7. Mathews. P.M and Venkatesan. K, "*Quantum Mechanics"*, Tata McGraw Hill, 2010.
8. Ajoy Ghatak and S. Lokanathan, "*Quantum Mechanics"*, Macmillan, 2009.
9. Michael. A, Nielsen & Isaac. L, Chuang, "*Quantum Computation and Quantum Information"*, Cambridge University Press, 2002.

NT2124	SCIENTIFIC RESEARCH METHODOLOGY	L	T	P	C
	Total contact hours 45	3	0	0	3
	Prerequisite				
	Nil				

PURPOSE

The ultimate aim is to make the learners to acquaint themselves in contemporary knowledge, latest trends in research methods, methodology, along with the research processes/designs. And to provide the strategic ideas to implement their own research designs with the hypothesis-testing, executions.

INSTRUCTIONAL OBJECTIVES

1.	Gain further insights into formulative, descriptive, explanatory, laboratory simulation research activities
2.	Determine the frequency with which something occurs or with which it is associated with something else (diagnostic research, measurements and impact analysis)
3.	Familiarized with the research codes, professional ethics and disruptive issues such as plagiarism/scientific-misconducts.
4	Establishing the casual relationship amongst the researchers, industry/academia and society

UNIT I - BACKGROUND (9 hours)

Earlier developments of scientific research since 1970-contemporary knowledge of research methods-The role of research in academia/industry - needs of research - understanding the modern research methods and its trends/goals - critical thinking and its evaluation parameters-developing and designing questionnaires - implementations – challenges /obstacles.

UNIT II – INFRASTRUCTURE AS A SERVICE (9 hours)

Indentifying The Key Resources: - Online/offline data, database search tools/algorithms, accessing the review articles, theses/dissertations, catalogs, citations – evaluation of quality Impact factor (QIF) of such resources – modeling using para- and meta analysis – parenting the records and documentation/compilation.

Unit III – FACT-FINDING CLASSIFICATIONS (9 hours)

Motivational research – Types of research: - Descriptive vs. Analytical, Applied Vs Fundamental, Qualititative Vs Quantitative, Conceptual Vs Empirical – Some other methods: - One-time research, longitudinal research, field-setting research, laboratory/simulation research, clinical/diagnostic research, historical/contemporary

research, conclusion/decision oriented research – Research approaches: - inferential, experimental, simulation techniques.

UNIT IV - RESEARCH METHODS VERSUS METHODOLOGY (9 hours)

Types of research techniques: - library research, field research, laboratory/simulation research – Research Process: - Extensive literature survey, Formulating the research problem, development of working hypotheses, preparing the research design, determining the sample design – Art of scientific writing: - formulation of abstracts, introductory remarks, descriptive writing, experimental/simulation approaches, measurements and analysis, referencing/citing, acknowledging – Compilations: - documentations, oral/paper presentations – Hypothesis-testing – Generalizations and interpretations, Acute authenticity and originality of the works

UNIT V - RESEARCH CODESAND PROFESSIONA ETHICS (9 hours)

Brief overview of ethics and science - different codes of ethics: - engineering ethics, standards of ethical conduct in science, global research ethics – scientific misconducts/plagiarism - case studies:- cloning scandal, miracle drug thalidomide and Jan Hendrik Schön case and the Baltimore affair - forcible needs of patenting the documents/articles/informations – authoring/mentoring (copyrights) :- credits/conflicts, errors and negligence, cost-effective and strategic solutions for authoring/patenting the assets.

REFERENCES

1. Adam Briggle and Carl Mitcham, "*Ethics and Science: An introduction*" Cambridge University press, 2012.
2. Gary Comstock, "*Research Ethics: A philosophical guide to the responsible conduct of Research*" Cambridge University Press, 2013
3. Ann Lahthorp, Kathleen Foss, "*Student cheating and plagiarism in the internet era: A wake up call*" Greenwood publishing group Inc. 2000.
4. Bright Wilson. E. "*An introduction to scientific research*" Dover publication, 1990
5. Robert. A, Day, Barbara Gastel, "*How to write and publish a scientific paper*" Cambridge University press 2012.
6. Anderson. B. H Duraston and Poole. M "*Thesis and assignment writing*", Wiley Eastern, 1997.
7. . Bordens. K. S and Abbott. B. B "*Research design and Methods*", Mc. Graw Hill (2008)
8. Graziano. A. M and Raulin. M. L "*Research Methods: A Process of Inquiry*", Pearson, 2007.
9. Leedy. P D,*"Practical Research – Planning and Design*", Pearson, 2005.
10. Research methodology: -An Introduction, For further reading, http://www.newagepublishers.com/samplechapter/000896.pdf

SEMESTER I

CAC2001	**Career Advancement Course For Engineers – I**	L	T	P	C
	Total Contact Hours – 30	**1**	**0**	**1**	**1**
	Prerequisite				
	Nil				
PURPOSE					
To enhance holistic development of students and improve their employability skills					

INSTRUCTIONAL OBJECTIVES

1. To improve aptitude, problem solving skills and reasoning ability of the student.

2. To collectively solve problems in teams & group.

3. Understand the importance of verbal and written communication in the workplace

4. Understand the significance of oral presentations, and when they may be used.

5. Practice verbal communication by making a technical presentation to the class

6. Develop time management Skills

UNIT I–BASIC NUMERACY

- Types and Properties of Numbers, LCM, GCD, Fractions and decimals, Surds

UNIT II-ARITHMETIC – I

- Percentages, Profit & Loss, Equations

UNIT III-REASONING - I

- Logical Reasoning

UNIT IV-SOFT SKILLS - I

- Presentation skills, E-mail Etiquette

UNIT V-SOFT SKILLS - II

- Goal Setting and Prioritizing

ASSESSMENT

Soft Skills (Internal)
Assessment of presentation and writing skills.

Quantitative Aptitude (External)
Objective Questions- 60 marks
Descriptive case lets- 40 marks*

Duration: 3 hours

*****Engineering problems will be given as descriptive case lets.

REFERENCE:

1. Quantitative Aptitude by Dinesh Khattar – Pearsons Publicaitons
2. Quantitative Aptitude and Reasoning by RV Praveen – EEE Publications
3. Quantitative Aptitude by Abijith Guha – TATA Mc GRAW Hill Publications
4. Soft Skills for Everyone by Jeff Butterfield – Cengage Learning India Private Limited
5. Six Thinking Hats is a book by Edward de Bono - Little Brown and Company
6. IBPS PO - CWE Success Master by Arihant - Arihant Publications(I) Pvt.Ltd – Meerut

SEMESTER II

CAC2002	**Career Advancement Course For Engineers – II**	L	T	P	C
	Total Contact Hours – 30	**1**	**0**	**1**	**1**
	Prerequisite				
	Nil				
PURPOSE					
To enhance holistic development of students and improve their employability skills					

INSTRUCTIONAL OBJECTIVES

1. To improve aptitude, problem solving skills and reasoning ability of the student.

2. To collectively solve problems in teams & group.

3. Understand the importance of verbal communication in the workplace

4. Understand the significance of oral presentations, and when they may be used.

5. Understand the fundamentals of listening and how one can present in a group discussion

6. Prepare or update resume according to the tips presented in class.

UNIT I-ARITHMETIC – II

- Ratios & Proportions, Mixtures & Solutions

UNIT II - MODERN MATHEMATICS

- Sets & Functions, Data Interpretation, Data Sufficiency

UNIT III – REASONING - II

- Analytical Reasoning

UNIT IV – COMMUNICATION - I

- Group discussion, Personal interview

UNIT V - COMMUNICATION - II

- Verbal Reasoning test papers

ASSESSMENT

Communication (Internal)

- Individuals are put through formal GD and personal interviews.
- Comprehensive assessment of individuals' performance in GD & PI will be carried out.

Quantitative Aptitude (External)

Objective Questions- 60 marks (30 Verbal +30 Quants)

Descriptive case lets- 40 marks*

Duration: 3 hours

*Engineering problems will be given as descriptive case lets.

REFERENCES

1. Quantitative Aptitude by Dinesh Khattar – Pearsons Publicaitons
2. Quantitative Aptitude and Reasoning by RV Praveen – EEE Publications
3. Quantitative Aptitude by Abijith Guha – TATA Mc GRAW Hill Publications

4. General English for Competitive Examination by A.P. Bharadwaj – Pearson Educaiton
5. English for Competitive Examination by Showick Thorpe - Pearson Educaiton
6. IBPS PO - CWE Success Master by Arihant - Arihant Publications(I) Pvt.Ltd - Meerut
7. Verbal Ability for CAT by Sujith Kumar - Pearson India
8. Verbal Ability & Reading Comprehension by Arun Sharma - Tata McGraw - Hill Education

SEMESTER III

CAC2003	**Career Advancement Course For Engineers – III**	L	T	P	C
	Total Contact Hours – 30	**1**	**0**	**1**	**1**
	Prerequisite				
	Nil				

PURPOSE

To develop professional skills abreast with contemporary teaching learning methodologies

INSTRUCTIONAL OBJECTIVES

At the end of the course the student will be able to

1	acquire knowledge on planning, preparing and designing a learning program
2	prepare effective learning resources for active practice sessions
3	facilitate active learning with new methodologies and approaches
4	create balanced assessment tools
5	hone teaching skills for further enrichment

UNIT I- DESIGN **(2 hrs)**

- Planning &Preparing a learning program.
- Planning & Preparing a learning session

UNIT II – PRACTICE **(2 hrs)**

- Facilitating active learning
- Engaging learners

UNIT III – ASSESSMENT **(2 hrs)**

- Assessing learner's progress
- Assessing learner's achievement

UNIT IV – HANDS ON TRAINING **(10 hrs)**

- Group activities – designing learning session
- Designing teaching learning resources
- Designing assessment tools
- Mock teaching session

UNIT V – TEACHING IN ACTION **(14 hrs)**

- Live teaching sessions
- Assessments

ASSESSMENT (Internal)

Weightage:

Design - 40%

Practice – 40%

Quiz – 10%

Assessment – 10%

REFERENCES

Cambridge International Diploma for Teachers and Trainers Text book by Ian Barker - Foundation books

Whitehead, Creating a Living Educational Theory from Questions of the kind: How do I improve my Practice? Cambridge J. of Education

AMENDMENTS

S.No.	Details of Amendment	Effective from	Approval with date