K.S. Rangasamy College of Technology

(Autonomous Institution)

Curriculum & Syllabus

of

M.Tech. Nano Science and Technology

(For the batch admitted in 2016 – 2017)

R 2014

Courses Accredited by NBA, Accredited by NAAC with 'A' Grade,
Approved by AICTE, Affiliated to Anna University, Chennai.

KSR Kalvi Nagar, Tiruchengode – 637 215.
Namakkal District, Tamil Nadu, India.

Vision

To Inspire, to Educate, to Connect to the world through continuous learning process in the interdisciplinary field of Nano Science and Technology for human welfare.

Mission

- To endow the young minds be an outstanding Intellectualist, Scientist and Entrepreneurs.
- To impart robust technology based education for the betterment of diversified fields via the concepts and ideas in Nano science and Technology.

Program Educational Objectives (PEOs)

- Our graduates are competent in the processing of nanostructured materials and to use for effective industrial applications.
- Our graduates demonstrate interdisciplinary proficiency both in theory and experiment.
- Our graduates apply the scientific concepts and mathematical analysis to bring out need based products.
- Our graduates demonstrate ethical responsibility with team spirit.

Programme Outcomes (Pos)

The graduates of Nano Science and Technology must have:

a. Ability to understand the importance and the impact of Nanoscience and technology
b. Ability to approach, analyse and bring out scientific solution for a given problem
c. Ability to implement multidisciplinary concepts and ideas for the development of innovative technologies.
d. Capability to extend the acquired knowledge for trouble shooting experimental errors.
e. Ability to demonstrate leadership, quality and entrepreneurship.
f. Demonstrate technical skills in operation and maintenance of sophisticated instrumentations.
g. Ability to protect their innovative research through IPR.
h. Ability to handle / approach challenging issues from industries.
i. Innovation for high quality research on par with international laboratories.
j. Ability to explore scientific projects for need based industry.
k. Ability to bring out good quality research proposal as well as research publications.

K.S. Rangasamy College of Technology - Autonomous Regulation	R 2014
Department	Nano Science and Technology
Programme Code & Name	PNT: M.Tech. Nano Science and Technology

K.S.Rangasamy College of Technology, Tiruchengode – 637 215	
Regulation	**R 2014**
Department	**Nano Science and Technology**
Programme Code & Name	PNT: M.Tech. Nano Science and Technology
Curriculum for the Programme under Autonomous Scheme	

Semester I

Course Code	Course Name	Hours/ Week			Credit
		L	T	P	C
THEORY					
40 PNT 101	Numerical Methods and Simulation	3	1	0	4
40 PNT 102	Quantum Mechanics	3	1	0	4
40 PNT 103	Nano Structured Materials	3	0	0	3
40 PNT 104	Advanced Materials	3	0	0	3
40 PNT 105	Synthesis of Nanostructured Materials	3	0	0	3
40 PNT E1*	Elective I	3	0	0	3
PRACTICAL					
40 PNT 1P1	Synthesis and Characterisation of Nanomaterials Laboratory - I	0	0	3	2
Total		18	2	3	22

Semester II

Course Code	Course Name	Hours / Week			Credit
		L	T	P	C
THEORY					
40 PNT 201	Characterisation Techniques	3	1	0	4
40 PNT 202	Nanocomposites	3	0	0	3
40 PNT 203	Nanosensors and Transducers	3	1	0	4
40 PNT 204	Nanolithography	3	0	0	3
40 PNT E2*	Elective II	3	0	0	3
40 PNT E3*	Elective III	3	0	0	3
PRACTICAL					
40 PNT 2P1	Nano Device Fabrication and Simulation Laboratory-II	0	0	3	2
40 PNT 2P2	Technical Report Preparation and Presentation	0	0	2	0
Total		18	2	5	22

Semester III

	THEORY				
40 PNT 301	Nanodevices	3	0	0	3
40 PNT E4*	Elective IV	3	0	0	3
40 PNT E5*	Elective V	3	0	0	3
PRACTICAL					
40 PNT 3P1	Project Work - Phase I	0	0	12	5
Total		9	0	12	14

Semester IV

	THEORY				
PRACTICAL					
40 PNT 4P1	Project Work - Phase II	0	0	40	15
Total		0	0	40	15

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Curriculum for the programme under Autonomous Scheme								
Elective I								
	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E11	Polymers in Nanotechnology	3	0	0	3	50	50	100
40 PNT E12	Biomaterials	3	0	0	3	50	50	100
40 PNT E13	Solid State of Nanotechnology	3	0	0	3	50	50	100
Elective II								
40 PNT E21	Nanobiotechnology	3	0	0	3	50	50	100
40 PNT E22	Industrial Nanotechnology							
40 PNT E23	Drug Delivery	3	0	0	3	50	50	100
40 PNT E24	Nanotechnology in Energy Conversion and Storage	3	0	0	3	50	50	100
Elective III								
40 PNT E31	Nanomedicine	3	0	0	3	50	50	100
40 PNT E32	Nanoelectronics	3	0	0	3	50	50	100
40 PNT E33	Nanotechnology in Automobiles	3	0	0	3	50	50	100
40 PNT E34	Electrochemical Energy Sources	3	0	0	3	50	50	100
Elective IV								
40 PNT E41	Micro and Nano Electro Mechanical Systems	3	0	0	3	50	50	100
40 PNT E42	Nanotechnology in Constructions	3	0	0	3	50	50	100
40 PNT E43	Nanotechnology in Semiconductor Devices	3	0	0	3	50	50	100
40 PNT E44	Research Methodology - Engineering and Management Studies	3	0	0	3	50	50	100
Elective V								
40 PNT E51	Nanosafety and Environmental Issues	3	0	0	3	50	50	100
40 PNT E52	Intellectual Property Rights	3	0	0	3	50	50	100
40 PNT E53	Product Design, Management and Entrepreneurship	3	0	0	3	50	50	100
40 PNT E54	Research Methodology - Science and Humanities	3	0	0	3	50	50	100

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Semester I								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT101	**NUMERICAL METHODS AND SIMULATION**	3	1	0	4	50	50	100
Objective(s)	With the present development of the computer technology, it is necessary to develop efficient algorithms for solving problems in science, engineering and technology. This course gives a complete procedure for solving different kinds of problems that occur in engineering numerically. At the end of the course the students would be acquainted with the basic concepts in numerical methods and their uses.							

SOLUTION OF EQUATION

Bisection Method – Newton Raphsan method – Method of False Position – Iteration Method – Secant Method – Muller's Method – Graeffe's Root-Squaring Method – Horner's Method.

SOLUTION OF EQUATION AND EIGEN VALUE PROBLEM

Solution of Linear Systems: Matrix Inversion Method, Gauss Elimination Method, Gauss-Jordan Method, Gauss-Seidal iteration Method, Solution of Tridiagonal Systems, Eigen value Problems: Eigen values of a symmetric Tridiagonal Matrix, Householder Method, QR Method.

NUMERICAL SOLUTION OF ORDINARY AND PARTIAL DIFFERENTIAL EQUATION

Picard's Method of Successive approximations – Euler's Method – Modified Euler's Method -Runge-Kutta Methods (Fourth order only). Boundary Value Problems: Finite Difference Method, Shooting Method, Cubic Spline Method. Poisson Equation – Laplace's Equation: Jacobi's Method, Gauss-Seidal Method, Parabolic Equations and Hyperbolic Equations.

NUMERICAL INTEGRATION

Numerical integrations by Trapezoidal and Simpson's 1/3 and 3/8 rules, Two and three point Gaussian quadrature formula, Romberg's Method – Double intergrals using trapezoidal and Simpson's rules. Finite Element Method: Rayleigh-Ritz Method, Galerkin Method.

ANOVA AND SIMULATION

Testing of hypothesis for small samples using t-test, F-test, χ^2 -test for independence of attributes and Goodness of fit. ANOVA : One way classification – Two way classification – Latin Square Design.
Simulation: Basic concepts of simulation – Advantages and limitations – Monte-Carlo Techniques – Uses of simulation.

Total hours to be taught : 60

Text book(s):

1	S.S. Sastry, "Introductory Methods of Numerical Analysis", Prentice-Hall of India, PVT. LTD,
2	M.K. Jain, S.R.K. Iyenkar and R.K. Jain, "Numerical Methods Problems and Solutions", New Age International Limited Wiley Eastern Limited, New Delhi, 1995.
3	Gupta, S.C, and Kapoor, J.N., "Fundamentals of Mathematical Statistics", Sultan Chand&sons, Ninth Edition, New Delhi, 2002.
4	Kanti Swarup, P.K.Gupta, Manmohan "Operation Research",Sultan Chand & Sons, New Delhi, 2004.

Reference(s):

1	Kandasamy.P, Thilakavathy.K and Gunavathy.K, "Numerical methods", (Revised Edition) S.Chand and company, New Delhi, 2005.
2	V.Sundaresan, K.S.Ganapathy Subramanian, K.Ganesan, "Resource Management Techniques (Operations Research)" A.R.Publications, Chennai, 2009.

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Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT 102	**QUANTUM MECHANICS**	3	1	0	4	50	50	100
Objective(s)	Impart the basic knowledge about the Quantum Mechanics and understand the various parameters like operator, Eigen function, angular momentum, the variation principles and approximate methods. Understand the Quantum Mechanics and apply the nanostructured materials.							

INTRODUCTION

Limitation of classical mechanics - Plank's quantum hypothesis - Einstein's photoelectric effect - Wave nature of particles - Heisenberg Uncertainty principle - Schrodinger's time dependent and independent wave equations - Particle in a one dimensional box - Harmonic oscillator.

WAVE MECHANICS

Linear operator - Hermitian operator - Linear harmonic oscillator - Operator method – Postulates of quantum mechanics - Equations in motion - Ehrenfests theorem - Hydrogen atom - Hydrogen orbitals - Matrix representation of wave functions.

OPERATORS AND COMPUTATION LAWS

Linear momentum operator – Properties of Hermitian operator – Angular momentum operators – Ladder operators – Parity operator – Commuting and non commuting operators – Commutation relation L_x and L_y - Commutation relation L^2 and L_x – Commutation relation L_+ and L_-.

VARIATION AT PRINCIPLES

Variation at method - Ground state of hydrogen molecule - Ground state of Helium atom –Perturbation theory in non-degenerate case - First order perturbation – Harmonic perturbation - Transition to continuous states.

APPROXIMATION METHODS

Klein-Gordon equation – Charge and current densities – Inadequacy of Klein-Gordon equation – Dirac's equation for a free particle - Dirac's matrices – Properties of Dirac's matrices – Negative energy states – Hartree-Fock equation.WKB Approximations-adiabatic approximation-Sudden approximation.

Total hours to be taught : 60

Reference(s) :

1	G. Aruldhass, "Quantum Mechanics", Prentice Hall of India pvt. Ltd. New Delhi, 2004.
2	Kurt Gottfried,Tung-Mowyan " Quantum Mechanics Fundamentals", Springer,2003.
3	Steven Weinberg "Lectures on Quantum Mechanics"USA Cambridge University press,2013
4	Ajoy Ghatak and Lokanathan "Quantum Mechanics:Theory and Applications", Kluwer Academic publications,2004
5	P M Mathews,K Venkatesan, "A Text Book of Quantum Mechanics", Tata McGraw Hill publications, 2007.
6	V K Thangappan "Quantum Mechanics" New Age International (P)Ltd,2003
7	Nouredine Zettili," Quantum Mechanics concepts and Applications"John wiley &sons Ltd.2009

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Semester I								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT 103	**NANO STRUCTURED MATERIALS**	3	0	0	3	50	50	100
Objective(s)	Impart the basic knowledge on nanoscience and technology. Understand the various process techniques available for the processing of nanostructured materials. Impart knowledge on the exotic properties of nanostructured materials at their nanoscale lengths. Acquire theknowledge above the various nanoparticles process methods and their skills. Study thereactive merits of various process techniques.							

INTRODUCTION

Introduction to Nanoscale materials - Atomic & molecular size. Scientific revolutions-nanotechnology application area. Scope of Nanoscience and technology.

NANOSTRUCTURES AND DIMENSIONS

Classification of nanostructures-zero, one, two and three dimensional nanostructures. Size Dependency in Nanostructures-Quantum size effects in nanostructures. Chemistry of tailored nano shapes.

METHODS OF PREPARATION

Classification - Synthesis of nanomaterials-Top down and bottom up approach. Method of nanomaterials preparation – Wet chemical (Sol gel) synthesis-Mechanical Milling.

NANOMATERIAL PROPERTIES

Surface to volume ratio. Surface properties of nanoparticles. Size dependent Mechanical, optical, electronic, magnetic, thermal and chemical properties. Size and shape dependent absorption spectra. Carbon nanotubes-physical properties and applications.

APPLICATIONS

Nano structured materials – applications – Anti Corrosive - Coating – Solar Cell -Types - Thermal Energy storage.

Total hours to be taught : 45

Reference(s) :

1	Mick Wilson, KamaliKannargare., Geoff Smith, “Nano technology: Basic Science and Emerging technologies”, Overseas Press, 2005.
2	Charles P. Poole, Frank J. Owens, “Introduction to Nanotechnology”, Wiley Interscience, 2003.
3	Mark A. Ratner, Daniel Ratner, “Nanotechnology: A gentle introduction to the next Big Idea”, Prentice Hall P7R:1st Edition, 2002.
4	T. Pradeep, “ Nano the Essential Nanoscience and Nanotechnology”, Tata McGraw hill, 2007.
5	J. Dutta, H. Hoffmann, “Nanomaterials”, Topnano-21, 2003.

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Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT 104	**ADVANCED MATERIALS**	3	0	0	3	50	50	100
Objective(s)	Understand the basic ideas about the materials and impart the knowledge about the properties and different applications of dielectric materials magnetic, semiconducting superconducting materials. Impart the knowledge about the new materials like smart materials, shape memory alloys and acquire the various physico-chemical properties of different materials.							

CRYSTALLOGRAPHY

crystalline solids-amorphous solids-lattice-basis-unit cell-crystallographic axes-primitives-lattice parameters-primitive cell -seven crystal systems - miller indices -crystal structure of materials- simple cubic - body centered cubic-face centered cubic – hexagonal structure-types of symmetry- bonding in solids-primary bonds-secondary bonds- imperfections-point, line, surface & volume – color centers

DIELECTRIC MATERIALS

Basic concepts of dielectric materials-dielectric properties - types of polarization - classification of dielectric materials based on temperature – Claussius-Mosotti relation Dielectric Constant and Dielectric Loss – breakdown mechanism - ferroelectric material –multiferroics - applications.

MAGNETIC MATERIALS

Dia-para-ferro and anti ferromagnetic materials and its properties -Ferrites-hard and soft magnetic materials-ferrites-structural and its properties-magnetic optical recording materials-magnetic computer data storage- - NMR imaging-MR imaging-storage-memory-recording and imaging

SEMICONDUCTING MATERIALS

Preparation of Semiconducting Materials-Band Gap-Direct, Indirect Band gap-Semiconductor Band Gaps-P-type-N-type –Fermi level-Fermidirac - Brillouin Zone-Advanced Semiconducting Materials-Functionalization of Charge –Hall effect-Charge Carriers

SMART MATERIALS

Shape memory alloys-Phase Transformations - Properties of SMA – classification of metal alloys-Ferrous alloys-Phase diagram-Titanium alloys- Nonferrous alloys - applications – Micro valve & pump. Metallic glasses – preparation – properties – applications.

Total hours to be taught : 45

Reference(s) :

1	V. Rajendran, Materials Science, Tata McGraw Hill, New Delhi, 2011.
2	A.J. Dekker, Solid state Physics, Macmillan India Ltd, New Delhi, 2012.
3	S.O. Pillai, Solid state Physics,New Age International(p)Ltd, 2007 Revised Edition
4	C. Kittle, Introduction to Solid State Physics 8th Edition, Wiley publishers, 2005.
5	Dimitris C Lagoudas, “Shape Memory Alloys Modeling and Engineering”, Springer 2008.
6	Christian Lexcellent “Shape Memory Alloys Handbook” Wiley-,ISTE 2013

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Semester I								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT105	**SYNTHESIS OF NANOSTRUCTURED MATERIALS**	3	0	0	3	50	50	100
Objective(s)	Impart the knowledge about the synthesis of nano structured materials. Understand the basic ideas about the materials synthesis through different methods like chemical, thin film, mechanical and etching methods. To understand the carbon based nano structured materials preparation.							

CHEMICAL METHODS

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

CVD AND PVD METHODS

CVD Chemical vapor deposition –Atmospheric pressure CVD (APCVD) – Low pressure CVD (LPCVD) - Plasma enhanced chemical vapor deposition (PECVD) - The HiPCOmethod - Photo-enhanced chemical vapor deposition (PHCVD)- LCVD Laser–InducedCVD. Physical vapor deposition- Sputter technologies- Diode sputtering - Magnetron sputtering- Ion beam (sputter) deposition, ion implantation and ion assisted deposition – Cathodicarc deposition - Pulsed laser deposition.

MECHANICAL METHODS

Micromilling - Microdrilling - Microgrinding processes - EDM micro machining - laser micro/nanomachining - Dry etching. isotropic anisotropic etching - Reactive ion etching- Magnetically enhanced RIE- Ion beam etching.

ETCHING TECHNIQUES

Wet etching of silicon - Isotropic etching - Anisotropic etching – Electrochemical etching - Vapor phase etching - Dry etching- Other etching techniques. Wet chemical etching.

CARBON BASED NANOMATERIALS

Synthesis method– carbon nanotube – nanorods – nanosprings – rings –nanosheets –other structures - chemical routes for nanotubes and nanorods – Ion beam induced nanostructures**.**

Total hours to be taught : 45

Reference(s) :

1	M. J. Jackson, “Micro fabrication and Nanomanufacturing”, CRC Press, 2005.
2	P.Rai-Choudhury, “Handbook of Micro lithography, Micro machining, and Microfabrication”, Vol. 2, SPIE Press, 1997.
3	G. Cao, “Nanostructures & Nanomaterials: Synthesis, Properties &Applications”Imperial College Press, 2004
4	W.T.S. Huck, “Nanoscale Assembly: Chemical Techniques (Nanostructure Scienceand Technology)”, Springer 2006
5	“Handbook of Nanoscience, Engineering and Technology”, Kluwer publishers, 2002.

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Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT 1P1	**SYNTHESIS AND CHARACTERISATION OF NANOMATERIALS LABORATORY-I**	0	0	3	2	50	50	100
Objective(s)	Understand the different methods and technical skills required to prepare the nanoparticles and characterization techniques							

1. Particles: Metal Oxide Nanoparticles (TiO_2/ZnO)
   Synthesis Method: Sol-Gel
   Characterisation Technique: XRD studies
2. Particles: Metal Oxide Nanoparticles (SiO_2/MgO)
   Synthesis Method: Ball mill
   Characterisation Technique: Particle size Distribution
3. Particles: Metal Oxide Nanoparticles (CuO/ZrO_2)
   Synthesis Method: Sonication
   Characterisation Technique: FTIR studies
4. Particles: Metal Nanoparticles (Ag/Au)
   Synthesis Method: Chemical reduction
   Characterisation Technique: EDAX analysis
5. Particles: Magnetite Nanoparticles (Fe_2O_3/Ni/Fe_2TiO_3)
   Synthesis Method: Co-Precipitation
   Characterisation Technique: VSM studies
6. Particles: Green Nanoparticles (Cu/SiO_2/Ag)
   Synthesis Method: Extraction/Reduction
   Characterisation Technique: UV and PL studies and band gap calculation
7. Particles: Nanocomposites (Al_2O_3-ZrO_2/TiO_2-SiO_2)
   Synthesis Method: Wet chemical
   Characterisation Technique: XRF studies
8. Particles: Metal Oxide nanoparticles (ZnO/MnO_2)
   Synthesis Method: Spray Pyrolysis
   Characterisation Technique: BET techniques
9. Particles: Nano Biomaterials (Bioactive glass (SiO_2/CaO/P_2O_5)/HAp)
   Synthesis Method: Hydrothermal Characterisation Technique: Zeta potential studies
10. Particles: Polymeric Nanofibers (PVA/MgO, TiO_2)
    Synthesis Method: Electro spinning
    Characterisation Technique: TEM/HRTEM analysis
11. Particles: Metal/Metal oxide Nanoparticles (Ag/TiO_2/ZnO)
    Synthesis Method: Precipitation
    Characterisation Technique: Antimicrobial studies
12. Particles: Perovskite Nanoparticles ($BaTiO_3$/$CaMgTiO_3$)
    Synthesis Method: Solid state preparation
    Characterisation Technique: Online Ultrasonics studies

Total Hrs	45

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Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT 201	**CHARACTERISATION TECHNIQUES**	3	1	0	4	50	50	100
Objective(s)	Understand the relative methods of various characterisation techniques and the basic knowledge about the different characterisation techniques. Impart the knowledge about the characterisation techniques and study each and every technique and acquire the knowledge to use the technique.							

MICROSCOPY

Optical microscopy – Confocal microscopy - Electron Microscopy: Scanning electron microscopy – Transmission electron microscopy – Scanning tunneling electron microscopy – Image collection in electron microscopes – Environmental transmission electron microscopy – In-situ measurements.

SCANNING PROBE MICROSCOPY

Scanning Probe microscopy – Atomic manipulations – Atomic force microscopy – Scanning probe lithography – Scanning near field optical microscopy – Secondary ion mass (SIMS) spectrometry.

SPECTROSCOPY

Optical absorption and emission spectroscopy – Basics - AAS – ICP OES – Infrared surface spectroscopy – Raman spectroscopy – Brillouin spectroscopy – Dynamic Light Scattering (DLS) – NMR Spectroscopy – Thermo gravimetric Analysis (TGA) – Differential Scanning Calorimetry (DSC) – Thermo mechanical Analysis (TMA).

MECHANICAL CHARACTERISATION

Modulus and load carrying capability of nano region/ compression - micro hardness – Fatigue – Abrasion and wear resistance – Super plasticity – Nano indentation – Nano tribology – Nano tribometre – Surface Force apparatus – Quartz crystal microbalance – Friction force microscope.

STRUCTURAL CHARACTERISATION

X- ray diffraction – Scherer formula – texturing - Micro strain macromolecular crystallography using synchrotron radiation – electron and neutron diffraction - Photoluminescence - Thermo luminescence – X-ray absorption Fine Structure (XAFS) – Extended X- ray absorption fine structure (EXAFS) – Electron spectroscopy for chemical Analysis (ESCA).

Total hours to be taught : 60

Reference(s) :

1	T.Pradeep, “Nano: The Essentials”, Tata McGraw Hill, New Delhi, 2007.
2	Charles P Poole Jr and Frank J Ownes, “Introduction to Nanotechnology”, John Wiley Sons, 2003.
3	Mick Wilson, KamaliKannangara, Geoff Smith, Michelle Simmons, BurkarRaguse, “Nanotechnology: Basic sciences and emerging technologies”, Overseas Press, 2005.
4	Willard, Merritt, Dean, Settle “Instrumental Methods of Analysis”, CBS PUBS & DISTS New Delhi 2007.
5	Ewing. Etal, “Instrumental Methods for Chemical Analysis”, Tata McGraw Hill Pub, New Delhi 2010.
6	Goodhew P.J. and Humphreys F.J., "Electron Microscopy And Analysis", Taylor and Francis, 2000.
7	Zhong Lin Wang, Characterization Of Nanophase Materials, Wiley-VCH, Verlag GmbH, Germany (2004).

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Semester II								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT 202	**NANOCOMPOSITES**	3	0	0	3	50	50	100
Objective(s)	Understand the science and technology behind the nanocomposites. Acquire the knowledge on nanocomposite properties, features and processing of various nanocomposites. Impart knowledge on various testing methods, applications and recycling.							

INTRODUCTION

Significance of composites, functions of matrix and reinforcement in composites, Classification of composites-particle reinforced-fibre reinforced-structural composite, Polymer, metal and ceramic matrix composites. Applications in automobiles-machine tools-aerospace and sports equipments.

PROCESSING OF NANOCOMPOSITES

Viscosity - Types of flow – Non-Newtonian Flow -Low-viscosity processing - Solvent processing - Particle behavior - In situ polymerization -Post-Forming - Melt, high -shear, and direct processing -Melting and softening - Melt processes with small shears or Low-shear rates flow – Melt processes with large deformations or high-shear rates - Thermo-kinetic processes.

PROPERTIES OF NANOCOMPOSITES

Physics of modulus – Continuum measurements – Yield – Fracture – Rubbery elasticity and visco elasticity – Surface mechanical properties –Diffusion and permeability – Features of nanocomposites – basics of polymer nanocomposites – Nano reinforcements – Matrix materials – Hazards of particles.

TESTING AND VALIDATION

Characterization – Experiment design – Sample preparation – Imaging –Structural characterization – Scales in nanocomposites – Texture – Electromagnetic energy –Visualization – Physicochemical analysis – Characterization of physical properties –Identification – Mechanical – Surface mechanical – Exposure – Barrier properties – Recipes and standards.

APPLICATIONS AND RECYCLING OFNANOCOMPOSITES

Nanocomposites – Optical, Structural Applications – Nanoparticulate Systems With Organic Matrices – Applications – Biodegradable Protein –Ceramics –Food Preservatives-Dental Materials- Automatic Components -Corrosion Protection- Properties And Property Changes Over Virgin Material- Contaminants-Role Of Contaminants In Property Change. Future Regulatory Issues On Polymer Nanocomposites Based On solid waste management.

Total hours to be taught : 45

Reference(s) :

1	Thomas E. Twardowski, Introduction to Nanocomposite Materials – Properties,Processing, Characterization, DesTech Publications, April 2007
2	Klaus Friedrich, StoykoFakivov, Zhony Shang, Polymer Composites from Nano – toMacro – scale, Springer, USA, 2005
3	Ray Smith, Biodegradable polymers for Industrial Applications, CRC Press, 2005
4	ManasChandar and Salil K. Roy, Plastics technology handbook, CRC Press, 2006
5	Yiu-Wing Mai and Zhong-Zhen Yu. Polymer nanocomposites CRC Press Boca Raton
6	ParagDiwan and AshishBharadwaj. Nanocomposites Pentagon Press
7	Nanocomposite Science and Technology Pulickel M. Ajayan , Linda S. Schadler , Paul V. Braun, 2006, Wiley-VCH

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Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT 203	**NANOSENSORS AND TRANSDUCERS**	3	1	0	4	50	50	100
Objective(s)	Impart knowledge about the nanosensors, trancducers and their application. Understand the basic about nanosensors and impart the knowledge for the different sensor application techniques.							

SENSORS AND THEIR CHARACTERISTICS

Active and Passive sensors – Static characteristic - Accuracy, offset and linearity – Dynamic characteristics - First and second order sensors – Physical effects involved in signal transduction- Photoelectric effect – Photoluminescence effect – Electroluminescence effect – chemiluminescence effect – Piezoelectric effect – Pyroelectric effect.

NANO BASED INORGANIC SENSORS

Density of states (DOS) – DOS IN 3D, 2D, 1D and 0D nanomaterials – one dimensional gas sensors:- gas sensing with nanostructured thin films – absorption on surfaces – metal oxide modifications by additives – surface modifications – nano optical sensors – nano mechanical sensors – plasmon resonance sensors.

TRANSDUCERS

Conductometric and capacitive transducers – optical waveguide based transducers – optical fiber based transducers – Interferometric optical transducers – surface plasmon resonance transducers – electrochemical transducers – soild state transducers – pn diodes or bipolar junction based transducers – schottky diode based transducers –Cantilever based tansducers.

GAS AND THERMAL SENSORS

Criteria for the choice of materials, Experimental aspects – materials, properties - measurement of gas sensing property, sensitivity - Discussion of sensors for various gases - Gas sensors based on semiconductor devices - Thermal energy sensors - temperature sensors - heat sensors- Optical and radiation sensors.

APPLICATIONS

Cantilever array sensors -Cantilever sensors for diagnosis of diabetes mellitus and cancer diagnosis -Nanotube based sensors for DNA detection and capnography -Nanowire based sensors and single viruses - detection of biomolecules – Night vision systems.

Total hours to be taught : 60

Reference(s) :

1	K. Goser, P. Glosekotter and J. Dienstuhl, “Nanoelectronics and Nanosystems-From Transistors to Molecular Quantum Devices”, Springer, 2004.
2	Herve Rigneault, Jean-Michel Lourtioz, Claude Delalande, Ariel Levenson, “Nanophotonics”, Wiley-IST - 2006.
3	W.R.Fahrner, “Nanotechnology and Nanoelectronics – Materials, Devices and Measurement Techniques” Springer, 2006.
4	K.E. Drexler, “Nano systems”, Wiley India, 2010.
5	Nanotechnology- Enabled sensors by Kouroush Kalantar – Zadeh, Benjamin Fry, Springer (2010)

K.S. Rangasamy College of Technology - Autonomous Regulation								R 2014
Department	Nano Science and Technology		Programme Code & Name		PNT : M.Tech – Nano Science and Technology			
Semester II								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT 204	**NANOLITHOGRAPHY**	3	0	0	3	50	50	100
Objective(s)	Understand the basic about nanolithography and impart the knowledge for the different lithography techniques. Impart knowledge about the lithography application of different industries and study the use of AFM in nano lithography							

BASICS IN LITHOGRAPHY

Lithography – Printing – Chemical process – Refinements – The modern process – Optical, micro, nanolithography – Lithography in artistic medium – Nanometer design for electronic circuits – Applications of nanolithography.

OPTICAL LITHOGRAPHY

Optical lithography – Light sources – Photo mask and alignment - Resolution in projection systems – Positive and negative photo resists – Ultraviolet lithography – X ray Lithography - Proximity printing – X ray masks – X ray sources – Synchrotron radiation – X ray projection – X ray resists – holographic lithography.

ION BEAM LITHOGRAPHY

Ion beam lithography - Focused ion beam – Point sources of ion – Ion column – Beam writing – Masked ion beam lithography – Ion projection lithography - Electron lithography – Electron optics – Raster scan and vector scan – Electron proximity / Projection printing - Electron resists – Electron beam applications.

MICRO-NANO LITHOGRAPHY

Microlithography – Microchips - Immersion lithography – Semiconductor processing – MEMS design - Nanolithography - Nanosphere lithography – Molecular self-assembly – Nanoimprint lithography - Dip-pen nanolithography - Soft lithography - Stereo -lithography - Nanoscale 3D shapes – NEMS design.

NANOLITHOGRAPHY TOOLS

Tools for nanolithography - Molecular manipulation by STM and AFM - Nanopattern synthesis – Nano scratching – Resist and imaging layers.

Total hours to be taught : 45

Reference(s) :

1	W.R.Fahrner, “Nanotechnology and Nanoelectronics – Materials, Devices, Measurement Techniques”, Springer, 2006.
2	David G.Bucknall,”Nanolithography and Patterning techniques in microelectronics”, CRC Press, 2005.
3	James R. Sheats, Bruce W. Smith, “Microlithography: Sciences and Technology”, CRC Press, 1998.
4	M.Gentili, Carlo Giovannella, Stefano Selci, “Nanolithography: A Borderland between STM, EB, IB, and X-Ray Lithographies”, 1st edition, Springer, 1994.
5	P. Rai-Choudhury, “Handbook of Microlithography, Micromachining, and Micro Fabrication”, IET, 1997.

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Semester II								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT 2P1	**NANO DEVICE FABRICATION AND SIMULATION LABORATORY-II**	0	0	3	2	50	50	100
Objective(s)	Understand the different device fabrication techniques and testing to acquire knowledge on the different devices using nanostructured materials and simulation software.							

1. Material: Nano coating (TiO_2/ZrO_2)
   Techniques: Ultrasonic spray coating
   Characterisation: FTIR-ATR and Fire redundant testing

2. Material: Thin film (Al_2O_3/ZrO_2)
   Techniques: Dip coating using nanosol
   Characterisation: SEM/HRSEM analysis

3. Material: Thin film (SiO_2/Ag/Au)
   Techniques: Spin coating
   Characterisation: AFM studies

4. Material: Nano coating (Bioactive glass ($SiO_2/CaO/P_2O_5$)/ceramics)
   Techniques: Electro deposition
   Characterisation: Nanoindentation testing

5. Material: Polymeric Scaffolds
   Techniques: Electro Spinning
   Characterisation: Physico-Chemical studies

6. Electrochemical studies - CV, charge/discharge, impedance and corrosion studies (MnO_2)

7. Design and fabrication of Nano Sensor and testing

8. Design and fabrication of Solar cell testing and IV measurements

9. Image analysis - AFM offline software and SEM/TEM images

10. Design and simulation of sensors (Temperature, Pressure, Gas)

11. Design and simulation of solar cell

12. Design and simulation of batteries

Any 9 experiments out of 12 experiments.

Total Hrs	45

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Semester II								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT 2P2	**TECHNICAL REPORT PREPARATION AND PRESENTATION**	0	0	2	0	100	00	100
Objective(s)	To provide exposure to the students to refer, read and review the research articles in referred journals and conference proceedings. To improve the technical report writing and presentation skills of the students.							
Methodology	• Each student is allotted to a faculty of the department by the HOD • By mutual discussions, the faculty guide will assign a topic in the general / subject area to the student. • The students have to refer the Journals and conference proceedings and collect the published literature. • The student is exposed to collect at least 20 such Research papers published in the last 5 years. • Using OHP/Power point, the student has to make presentation for 15-20 minutes followed by 10 minutes discussion. • The student has make two presentations, one at the middle and the other near the end of the semester. • The student has to write a Technical report for about 30-50 pages (Title page, One page Abstract, review of research paper under various subheading, Concluding remarks and List of References). The technical report has to b submitted to the HOD one week before the final presentation, after the approval of the faculty guide.							

Execution	Week	Activity
	I	Allotment of Faculty Guide by the HOD
	II	Finalizing the topic with the approval of Faculty Guide
	III-IV	Collection of Technical papers
	V – VI	Mid semester presentation
	VII – VIII	Report writing
	IX	Report Submission
	X-XI	Final technical presentation

Evaluation	• 100 % Continuous Assessment • 2 Hrs/week	
	Component	Weightage
	Phase – I Presentation	25 %
	Phase – II Presentation	25 %
	Report preparation and Submission	30 %
	Final presentation	20 %
	Total	100%

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Semester III								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT 301	**NANODEVICES**	3	0	0	3	50	50	100
Objective(s)	To understand the development of nanoelectronics. To study the principle behind the nanodevices. To explore the application of nanodevices. To understand and study the molecular and bioelectronics on nano application.							

QUANTUM DEVICES

Quantum electronic devices – Electrons in mesocopic structures – Short-channel MOS transistor – Split gate transistor – Electron wave transistor – Electron spin transistor – Quantum cellular automata – Quantum dot array – Quantum computer- Bit and Qubit – Coherence and Entanglement – Quantum parallelism.

TUNNELING DEVICES

Tunneling element – Tunnel effect and tunneling elements -Tunneling diode – Resonant tunneling diode – Three-terminal resonate tunneling devices -Technology of RTD - Memory applications – Basics logic circuits – Dynamic logic gates - Digital circuits design based on RTBT – Single electron transistor (SET).

SUPERCONDUCTING DEVICES

Basics - Macroscopic characteristics – Macroscopic model - Super conducting switching devices – Cryotron - Josephson tunneling devices - Elementary circuits – Associative or Content – Addressable memory - SQUID – Flux quantum device – LC - Gate – Magnetic flux quantum – Quantum cellular automata - Quantum computer with single flux devices – SFQD - RSFQD – Application of superconducting devices.

CHALLENGES IN NANODEVICES

Limitations of integrated electronics - Survey of limits – Replacement of technologies – Energy supply and Heat dissipation – Parameter spread as limiting effect – Limits due to thermal particle motion - Debye length – Thermal noise - Reliability as limiting factor – Physical limits – Thermodynamic limits - Relativistic limits – Equal failure rates by tunneling and thermal noise.

BIOELECTRONICS

Bioelectronics – Molecular processor – DNA analyser molecular electronics – Switches based on fullerenes and nanotubes – Polymer electronic – Self assembling circuits – Optical molecular memories – DNA computer – Information processing with chemical reaction – Nanomachines – Parallel processing.

Total hours to be taught : 45

Reference(s) :

1	K. Goser, P. Glosekotter and J. Dienstuhl, “Nanoelectronics and Nanosystems-From Transistors to Molecular Quantum Devices”, Springer, 2004.
2	Herve Rigneault, Jean-Michel Lourtioz, Claude Delalande, Ariel Levenson, “Nanophotonics”, ISTE.
3	W.R.Fahrner, “Nanotechnology and Nanoelectronics – Materials, Devices and Measurement Techniques” Springer, 2006.

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Semester III								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT 3P1	**PROJECT WORK - PHASE I**	0	0	12	2	100	00	100
Objective(s)	To exposure the students with Innovative Ideas. To provide exposure to the students to new areas of nanotechnology Introduction to solve a scientific problem in both practically and theoretically.							
Methodology	• Each student is allotted to a faculty of the department by the HOD • By mutual discussions, the faculty guide will assign a topic in the general / subject area to the student. • The students have to refer the Journals and conference proceedings and collect the published literature. • The student is exposed to collect at least 25 such Research papers published in the last 5 years. • Using Power point, the student has to make presentation for 15-20 minutes followed by 10 minutes discussion. • The student has make two presentations, one at the middle and the other near the end of the semester. • The student has to write a mini project report for about 30-50 pages (Title page, One page Abstract, review of research paper under various subheading, Concluding remarks and List of References). The project report has to be submitted to the HOD one week before the final presentation, after the approval of the faculty guide.							

Execution	Week	Activity
	I	Allotment of Faculty Guide by the HOD
	II	Finalizing the topic with the approval of Faculty Guide/ Industrial visit
	III-IV	Collection of Scientific papers
	V – VI	Mid semester presentation
	VII – VIII	Report writing
	IX	Report Submission
	X-XI	Final presentation

Evaluation	• 100 % Continuous Assessment • 3 hrs/week and 2 credits	
	Component	Weightage
	Phase – I Presentation	25 %
	Phase – II Presentation	25 %
	Report preparation and Submission	30 %
	Final presentation	20 %
	Total	100%

K.S. Rangasamy College of Technology - Autonomous Regulation								R 2014
Department	Nano Science and Technology	Programme Code & Name		PNT : M.Tech – Nano Science and Technology				
Semester IV								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT 4P1	**PROJECT WORK - PHASE II**	0	0	40	10	50	50	100
Objective(s)	To make the students with Innovative Ideas. To provide exposure to the students to new areas of nanotechnology. To solve a scientific problem in both practically and theoretically							
Methodology	• Each student is allotted to a faculty of the department by the HOD • By mutual discussions, the faculty guide will assign a topic in the general / subject area to the student. • The students have to refer the Journals and conference proceedings and collect the published literature. • The student is exposed to collect at least 50 such Research papers published in the last 5 years. • Using Power point, the student has to make presentation for 15-20 minutes followed by 10 minutes discussion. • The student has make two presentations, one at the middle and the other near the end of the semester. • The student has to write a project report for about 30-50 pages (Title page, One page Abstract, review of research paper under various subheading, Concluding remarks and List of References). The project report has to be submitted to the HOD one week before the final presentation, after the approval of the faculty guide.							

Execution	Week	Activity
	I	Allotment of Faculty Guide by the HOD
	II	Finalizing the topic with the approval of Faculty Guide
	III-IV	Collection of Scientific papers
	V – VI	Mid semester presentation
	VII – VIII	Report writing
	IX	Report Submission
	X-XI	Final presentation

Evaluation	• 50 % Continuous Assessment and 50 % End semester exam • 30 hrs/week and 20 credits	
	Component	Weightage
	Phase – I Presentation	15 %
	Phase – II Presentation	15 %
	Report preparation and Submission	20 %
	Viva - Voce	50 %
	Total	100%

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Elective I								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E11	**POLYMERS IN NANO TECHNOLOGY**	3	0	0	3	50	50	100
Objective(s)	With the present development of nanotechnology in organic material, it is necessary to develop effective performance for the future trends. This course gives fundamental concepts and application for solving different kinds of problems that polymers involving technologically. At the end of the course the students would be acquainted with the basic concepts in several kinds of polymers in nanotechnology and their uses.							

INTRODUCTION

Classification, formation of polymers - chain growth and step growth polymerisation, copolymerisation – electropolymerisation thermoplastics and thermosets – micro - nanostructures in polymers – polymer length, molecular weight, amorphous and crystalline.

PROPERTIES

Polymer morphology- Crystallinity, Tensile strength, Surface tension, Young's modulus – Phase behaviour-glass transition temperature, mixing behavior, inclusion of plasticizers – types of polymerisation – mechanisms– polymer degradation.

NANOPOLYMERS

Preparation and characterisation of diblock copolymer based nano hybrids, Nanoparticles polymer ensembles; Assembly of polymer – polymer nanocomposite from polymerisation; polymers/clay nanocomposites.

NANOPOLYMERS IN ELECTRONICS

Printing and patterning techniques - nanoscale behaviour in organic transistors - transition of sensing response by organic transistor from micro to nanoscale - organic field effect transistor, organic light emitting diode. Molecular electronics.

NANOPOLYMERS IN TEXTILES

Hydrogels, synthetic and natural polymers in electrospinning - controlling parameters and morphology of nanofibers, nanoparticles - electro static self assembled nanolayer films and coating in textiles.

Total hours to be taught : 45

Reference(s) :

1	Harry R allcock, Frederick W lampe and James E Mark," Contemporary polymer chemistry", person education, 2003
2	K cousins, keith cousins," polymers in electronics" smithers Rapra technology publishers, 2006
3	P J Brown and K Stevens," nanofibers and nanotechnology in textiles" CRC press, 2007
4	Frances Gardiner, Eleanor carter,: polymer electronics – a flexible technology", ismithers, 2009

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Elective I								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E12	**BIOMATERIALS**	3	0	0	3	50	50	100
Objective(s)	Understand the basic properties of biomaterials and the classes of biomaterials implant, ceramics, alloys, polymers, knowledge about DNA nanotechnology and understand basic Characterisation techniques. To understand the applications of biomaterials.							

INTRODUCTION

Biomaterials - first generation - second generation - general characteristics – properties – biological systems.

BIOMATERIALS

Third generation biomaterials – characteristics - biomaterials in tissue engineering - enzyme conjugate - DNA conjugates - micro array technologies - micro-nanotechnology – microfabrication - nanofabrication between biological materials - molecular machines.

BIOACTIVE AND BIODEGRADABLE MATERIALS

Bioactive materials - bioceramics for implant coating: calcium phosphates – hydroxyapatite - metals – alloys – ceramics – composites - natural composites and other biomedical alloys. Cardiovascular implants:
Cardio pacemaker-blood substitutes – biopolymers – biomembranes – bioactive glasses.

TISSUE ENGINEERING

Tissue Engineering :engineering biomaterial to control cell function – building structure into engineered tissues - fibrous proteins and tissue engineering – scaffolds for tissue fabrications – materials for scaffolds - materials for hydrogel scaffolds - scaffolds fabrication technologies – nano - featured and bioactive scaffolds – nano - fiber scaffolds - nanocomposite scaffolds - scaffolds for stem cells - micro and nanopatterned scaffolds.

DNA TECHNOLOGY

Introduction - DNA nanotechnology-structural DNA assembly – DNA nano pore – arrays - DNA detection, sorting, sequencing - DNA studies by AFM - DNA based computation - PCR amplification of DNA fragments - molecular surgery of DNA - nanoscale organisation - characterisation.

Total hours to be taught : 45

Reference(s) :

1	SV Bhat, Biomaterials(2nd Edition),Narosa Publishing House, New delhi-2005
2	C.M. Niemyer & C.A. Mirkin, “Nanobiotechnology: Concepts, Applications and Perspectives”, Wiley VCH Verlag GMBH & Co, 2004.
3	Raplph et al, “Nanoscale Technology in Biological Systems”, CRC Press, 2005.
4	Joon B. Park, R.S. Lakes, “Bio Materials: An Introduction”, Birkhäuser 2nd Edition 2006
5	Challa Kumar (Ed.) “Tissue, cell and Organ Engineering”, Nanotechnologies for life sciences,WileyVCH 2009

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Elective I								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E13	**SOLID STATE OF NANOTECHNOLOGY**	3	0	0	3	50	50	100
Objective(s)	To impart the basics of solid state physics and the knowledge of structure, electrical, optical, dielectric and magnetic properties of different materials to understand the nanoscience and nanotechnology.							

STRUCTURE AND IMPERFECTIONS IN CRYSTALLINE SOLIDS

Metallic crystal structures: Cubic and HCP system, packing factor, linear and planar densities, polymorphism and allotropy. Ceramic crystal structure: Radius ratio rules, AX-type, A_mX_p-type and $A_mB_nX_p$-type crystal structures, crystal structure from close packing of anions, ceramic density computation. Determination of crystal structure. Point defects: vacancies and self-interstitials, specification of composition. Dislocations: Burger vector. Interfacial defects- Bulk or Volume defects- Influence of imperfections and impurities on electrical, optical and mechanical properties of materials.

ELECTRICAL PROPERTIES OF SEMICONDUCTORS

Fermi Dirac distribution- Effect of temperature on Fermi Distribution function- Density of States- Sommerfeld's theory of electrical conductivity- Band theory of solids- Overlapping of energy bands- Kronig Penney model- Motion of electron in one dimension according to band theory- Brillouin zones- Band model for metals, semiconductors and insulators.

OPTICAL PROPERTIES

Optical Reflectance: Kramers-Kronig relation- Electronic interband transitions. Excitons: Frenkel excitons- Alkali halides, Molecular crystals-Weakly bound excitons- Exciton condensation into electron-hole drops.

DIELECTRIC PROPERTIES

Macroscopic description of the static dielectric constant-static electronic and ionic polarizabilities-Orientation polarization- static dielectric constant of gases- Lorentz internal field-Dielectric losses and relaxation time. Classification and properties of ferroelectrics- Ferroelectric domains-Piezoelectric materials and applications.

MAGNETIC PROPERTIES

Ferromagnetism- Domain theory- Magnetic hysteresis- Weiss molecular field theory-Heisenberg's theory- Magnetic anisotropy- Domain walls-Exchange energy- Antiferromagnetism- Ferrites: Structure and properties and applications.

Total hours to be taught : 45

Reference(s) :

1	Callister W D, "Materials Science and Engineering", Wiley Publications, 2010.
2	James F Shackelford," Introduction to Materials Science for Engineers", Prentice Hall, 2008.
3	Dekker A J, "Solid State Physics", Macmillan Publications, 1970.
4	Pillai S O, "Solid State Physics", New Age International, 2005
5	Michael Shur, "Physics of Semiconductor Devices", Prentice Hall,1995.

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Elective II								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E21	**NANOBIOTECHNOLOGY**	3	0	0	3	50	50	100
Objective(s)	Understand the basic knowledge of Nanobiotechnology and DNA structures. Understand the application of nanomaterials in biotechnology and acquire the knowledge about the DNA, proteins, amino acids, drug delivery, biomedicine etc.,							

INTRODUCTION

Interdisciplinary areas of biotech and nanoscience - biological systems – cells – cellular components - nucleic acids and proteins refinement and application of instruments – to generate and manipulate nanostructured materials to basic and applied studies.

INTERPHASE SYSTEMS

Interphase systems of devices for medical implants – nano-biometrics – introduction – lipids as nano-bricks and mortar: self assembled nanolayers – nano analytical.

PROTEIN BASED NANOSTRUCTURES

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

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.

APPLICATIONS

Metal nanoparticles and nucleic acid and protein based recognition groups – application in optical detection methods – nanotechnology in agriculture – fertilizers and pesticides - natural nanocomposites – silica nanoparticles in maize growth.

Total hours to be taught : 45

Reference(s) :

1	CM, Niemeyer, C.A. Mirkin, “Nanobiotechnology: Concepts, Applications and Perspectives”, Wiley – VCH, 2004.
2	T. Pradeep, “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.

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Elective II								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E22	**INDUSTRIAL NANOTECHNOLOGY**	3	0	0	3	50	50	100
Objective(s)	Understand the applications of nanomaterials in industries and study the relative methods of various principles and their industrial applications							

NANOSENSORS AND ACTUATORS

Micro and nano electromechanical systems- fabrication process, choice of materials, calculations, performance of different nanostructures, advantages and limitations of various approaches-Applications-thermal-radiation magnetic-chemical – pressure-mechanical nanosensors - micro actuators.

MOLECULAR ELECTRONICS

Magnetism in solids-magnetic domains - Nanomagnetic properties of materials - nanostructure relationships - Fabrication and properties of nanostructured magnets-Photoinduced magnetism – spintronics - Nanomagnetic probes - Electronic magneto transport and micro magnetic modeling.

NANOAGRICULTURE AND FOOD TECHNOLOGY

Nanotechnology in agriculture-precision farming-smart delivery system-insecticides-potential of nano fertilizers-nanotechnology in food industry-packaging-food processing-food safety and security-contaminant detection-Soil repellence

TEXTILE AND MECHANICAL

Modern textiles -Lightweight bullet proof vests and shirts- color changing property- water proof and germ proof-cleaner kids cloths- wired and ready to wear-paints-catalysis-lubricants

AUTOMOBILE APPLICATIONS

Nano engineered materials-automotive products-nanoparticles fillers for tires-efficiency of nanofuel materials-nanostructured lubricants-thermoelectric material for temperature control coolant-interior-automotive paints-dirt resistant paints-vehicles windows and wipers-automotive textiles

Total hours to be taught : 45

Reference(s) :

1	J. Verdeyen, “Laser Electronics”, III Edition, Prentice Hall, 2007.
2	Vinod Kumar Khanna, Nanosensors: Physical, Chemical, and Biological ,CRC Press 2011
3	Reynolds, M.Pomeranty“Electro responsive molecules and polymeric systems”, Skotheim T. Marcel Dekker New York, 1991.
4	A. Yariv, “ Optical Electronics”, Oxford University Press,2008
5	M C Petty, M R Bryce, D Bloor (eds.), ’Introduction to Molecular Electronics’, Edward Arnold, London, 1995 (ISBN 0-340-58009-7)
6	G Hadziioannou, P F van Hutten, ’Semiconducting Polymers: Chemistry, Physics, and Engineering’, Wiley-VCH, 2000 (ISBN 3-527-29507-0)
7	P. BrownK Stevens “Nanofibers and Nanotechnology in Textiles” Woodhead Publishing 2007
8	Jennifer Kuzma and Peter VerHage, *Nanotechnology in agriculture and food production,* Woodrow Wilson International Center,(2006).
9	Lynn J. Frewer, Willehm Norde, R. H. Fischer and W. H. Kampers, *Nanotechnology in the Agri-food sector,* Wiley-VCH Verlag, (2011).

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Elective II								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E23	**DRUG DELIVERY**	3	0	0	3	50	50	100
Objective(s)	To provide exposure to the students on biophysics in nanotechnology. To explore the cancer therapy and drug delivery system. To study the various devices used for nanotechnology							

INTRODUCTION

Modes of drug delivery, ADME hypothesis – controlled drug delivery, site specific drugs , barriers for drug targeting, passive and active targeting, strategies for site specific, time and rate controlled delivery of drugs, antibody based and metabolism - based targeting.

NANO PARTICLES IN DRUG DELIVERY

Nanoparticles surface modification, bio conjugation, pegylation, antibodies, and cell - specific targeting and controlled drug release, multi - functional gold nanoparticles for drug delivery: virus based - nanoparticles.

DENDRIMERS AS DRUG CARRIERS

Synthesis – nanoscale containers – nanoscaffold systems – gene transfection, biocompatibility polymer micelles as drug carriers, polymers nanotubes - magnetic nanoparticles as drug carriers.

LIPOSOMES FOR DRUG DELIVERY AND TARGETING

Classification and preparation of liposomal nanoparticles. liposomes for pharmaceutical and cosmetic applications, liposomal drug carriers in cancer therapy, lipid-DNA complexes, viral gene transfection systems, lipid based drug delivery systems for peptide and protein drug delivery, liposomal anticancer and antifungal agents.

APPLICATIONS

Targeted delivery through enhanced permeability and retention. folate receptors, targeting through angiogenesis, targeting to specific organs or tumor types, tumor-specific targeting: breast cancer, liver, targeting tumor vasculature for Imaging, delivery of specific anticancer agents: such as Paclitaxel, Doxorubicin,5-Fluorouracil.

Total hours to be taught : 45

Reference(s) :

1	Drug Delivery and Targetting, A.M.Hillery, CRC Press, 2002.
2	NANOTHERAPEUTICS: Drug Delivery Concepts in Nanoscience edited by AlfLamprecht ISBN 978-981-4241-02-1 981-4241-02-4
3	Nanoparticulate Drug Delivery Systems Deepak Thassu, Michel Deleers (Editor),Yashwant Pathak (Editor) ISBN-10: 0849390737 ISBN-13: 9780849390739.
4	Bio-Applications of Nanoparticles Warren C.W. Chan ISBN: 978-0-387-76712-3.
5	Lisa Brannon-Peppas, James O. Blanchette Nanoparticle and targeted systems for cancer therapy Advanced Drug Delivery Reviews 56 (2004) 1649– 1659.
6	Irene Brigger, Catherine Dubernet, Patrick Couvreur Nanoparticles in cancer therapy and diagnosis Advanced Drug Delivery Reviews 54 (2002) 631–651.

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Elective II								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E24	**NANOTECHNOLOGY IN ENERGY CONVERSION AND STORAGE**	3	0	0	3	50	50	100
Objective(s)	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.							

INTRODUCTION

Nanotechnology for sustainable energy- Energy conversion process, indirect and direct energy conversion- Materials for light emitting diodes-batteries-advanced turbines-catalytic reactors-capacitors-fuel cells.Solar energy conversion: Photovoltaic- Photoelectrochemical- Photothermal and Thermoelectric systems.

RENEWABLE ENERGY

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.

BATTERIES

Basic concepts-Components & Classification of Cells and Batteries-Operation of a Cell- Energy-Specific Energy and Energy Density -Factors affecting Battery Performance-design-General Characteristics-Selection and Application -Types - Primary Batteries - Reserve Batteries & sodium beta-secondary batteries-metal-air batteries.

FUEL CELL AND FLUIDIC SYSTEMS

Hydrogen storage methods - metal hydrides - size effects - hydrogen storage capacity. Micro-fuel cell technologies, integration and performance for micro-fuel cell systems -thin film and micro fabrication methods. - novel micro fluidic devices - nano engines – driving mechanisms - power generation – micro channel battery - micro heat engine (MHE) fabrication - thermocapillary forces -Thermocapillary pumping (TCP) - piezoelectric membrane.

SOLAR ENERGY SYSTEMS

Solar cells - types of solar cells - semiconducting material- Solar cell properties and design- p-n junction photodiodes- depletion region- electron and holes transports - charge carrier generation - I-V characteristics - output power -Single junction and triple-junction solar panels - metal-semiconductor heterojunctions.

Total hours to be taught : 45

Reference(s) :

1	Introduction to Solid State Physics, C.Kittel, a chapter about Nanotechnology, Wiley,2004
2	Nanotechnology - Molecularly Designed Materials – G.M.Chow and K.E.Gonslaves (American chemical society)
3	Thomas Reddy, “Linden’s Handbook of Batteries”, McGraw Hill Professional, USA, 2010
4	Ogumi Z, “Battery/Energy technology (General)”, The Electrochemical Society, USA 2010
5	Dudney N, “Metal/Air and Metal/Water Batteries”, The Electrochemical Society, USA 2010
6	Principles of Solar Engineering, D. Yogi Goswami, Taylor and Francis, 2000, ISBN 10: 1-56032-714-6
7	Solar Cells: Operating Principles, Technology and system Applications, Martin A. Green,Published by the University of New South Wales, 1998, ISBN 0 85823 580 3.

K.S. Rangasamy College of Technology - Autonomous Regulation								R 2014
Department	Nano Science and Technology	Programme Code & Name		PNT : M.Tech – Nano Science and Technology				
Elective III								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E31	**NANOMEDICINE**	3	0	0	3	50	50	100
Objective(s)	Understand the principle behind nanomedicine and understand the application of Nanomaterials in medicine. Impart knowledge about drug delivery systems and nanosensors. Impart the knowledge to apply the Nanomaterials in different medical applications and gain the knowledge for the solution of right nanomaterials for biomedical applications.							

NANOBIOMOLECULES

Structure property relationship of biological materials: nano structure of proteins and polysaccharides – structure property relationship of tissues, bones and teeth - collagen rich tissues - elastic tissues - preparation of nano biomaterials – polymeric scaffolds collagen – elastins – mucopolysaccharides – proteoglycans - cellulose and derivates – dextrans – alginates – pectins - chitin.

TYPES OF NANOBIOMOLECULES

Introduction - development of nano medicines – nano shells – nano pores – Tecto-dendrimers – nano particle drug system for oral administration – drug system for nasal administration – drug system for ocular administration – nanotechnology in diagnostic application.

BIONANO PARTICLES

Gold and silver nanoparticles in cancer targeting and treatment – nanoparticles in treatment of breast cancer – chemotherapy – active and passive cancer tissue targeting – micro fluidics – chemotherapeutic agents – immunotherapy – vaccine immunotherapy – radiotherapy – thermotherapy – photo dynamic therapy – nano particulate targeting.

NANOBIOSENSORS

Introduction to nanobiosensors – organization techniques – ion sensing at nanoparticle surface – cation sensing – anion sensing – surface confined chemical sensors – nanoparticles sensors – calorimetric sensing – vapor phase sensing – raman sensing at surfaces – electro analytical sensing – plasma and optical sensing.

BIOLOGICAL THERAPEUTICS

Introduction – antibody conjugated nanoparticles – conjugated nanoparticles interaction with biological surfaces – biomedical nanoparticles – liposome's – dentrimers – different types of drug loading – drug release – biodegradable polymers – applications.

Total hours to be taught : 45

Reference(s) :

1	J. B Park, "Biomaterials Science and Engineering", Plenum Press, New York, 1984.
2	T. Pradeep, "Nano: The essentials" , McGrew – Hill, 2007
3	J.J. Davis, Dekker, "Encyclopedia of Nanoscience and nanotechnology"
4	Natalie P. Praetories and Tarun K. Mandal, Recent Patents on Drug Delivery& Formulation
5	Y. Lu, S.C. Chen, Advanced Drug Delivery Reviews.

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Elective III								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E32	**NANOELECTRONICS**	3	1	0	4	50	50	100
Objective(s)	Understand the basic about the semiconductor & magnetic materials. Impart the knowledge about the nanostructured semiconducting materials and spintronic. Understand the different applications of nano semiconductor & organic materials in different areas.							

BASICS OF NANOELECTRONICS

Physical concepts – Quantization of action, charge and flux – electrons in potential well – photons interacting with electrons in solids – diffusion processes – basic information theory – data & bits – data processing – 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.

SILICON TECHNOLOGY

Development of microelectronics-nanostructure region-complexity problem-challenges in nanoelectronics-potentials of silicon technology-semiconductor base material-band diagram of semiconductor- homogeneous semiconductor-transistor integration-types-applications.

NANOELECTRONIC MATERIALS

Nanoelectronics Materials Synthesis – size dependent properties – 0D -1D – 2D – 3D nanostructures – Molecular beam epitaxy – MOCVD – Chemical routes – Nanoparticles on polymers – Pulsed laser deposition – Ion beam assisted techniques including embedded nanoparticles.

ORGANIC ELECTRONICS

Display Devices- Information displays –Organic Light Emitting Diodes OLED-Organic Thin-Film Transistors (OTFT)- Organic Photovoltaic's (OPV)- Organic Photo detectors (OPD)- HB-LEDs-Thin film Organic Devices-Organic Thin Film Semiconductors**-** Materials for Organic Semiconductors- Flexible Transparent and organic Solar Cell-Flexible Electronics- Future of Organic Electronic Manufacturing

SPINTRONICS

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.

Total hours to be taught : 60

Reference(s) :

1	L.Banyai and S.W.Koch, "Semiconductor Quantum Dots", World Scientific, 1994
2	J.H. Davies, "An introduction to the physics-at low dimensional semiconductors", Cambridge Press, 1998.
3	Keith Barnham, Dimitri Vvedensky, "Low-dimensional semiconductor structures: fundamentals and device applications", Cambridge University Book, 2001.
4	Rainer Waser " Nanoelectronics and Information Technology :Advanced Electronic Materials and Novel Devices",Wiley-VCH(2003)
5	Karl Goser, Peter Glosekotter, Jan Dienstuhl, "Nanoelectronics and Nanosystems", Springer, 2004.
6	V.Mitin, V.Kochelap,M.Stroscio,"Introduction to Nanoelectronics", Cambridge University Press,2008.
7	*Organic Electronicsii*: More *Materials and Applications*. Hagen Klauk (Editor). ISBN: 978-3-527-32647-1. 440 pages. January 2012.

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Elective III								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E33	**NANOTECHNOLOGY IN AUTOMOBILES**	3	0	0	3	50	50	100
Objective(s)	To provide exposure to the students on nanotechnology in automobiles. To study the various materials used in automobiles systems and its application							

NANOFUELS

Nanofuel-Engine performance-Emissions-Burning characteristics-Ignition delay-Stable suspensions of nanoparticles of Al, Fe and Boron in diesel were used as fuels- Fuel consumption materials -specific fuel consumption for Al as compared to diesel. -reduced environmental impact materials- efficiency of nanofuel materials- nanostructured lubricant -reduced frictional loss- Reduced friction-surface finish and affinity or oil

NANOFLUIDS

Synthesis of Nanofluids- methods-Smart Cooling Nanofluids- thermal properties of nanofluids- Thermal insulation -higher operating temperature-Reduced friction -surface finish and affinity or oil-Reduce dimension weight -replaces cast iron block/liner- Nanofluids for Sensing Applications - Heat transfer improvement using nanofluids-nanofluids for solar collectors- molecular fluid-advanced flow and heat transfer fluids-magnetic nanofluids-Nanofluid in Fuel Brake and Other Vehicular Nanofluids Cooling of Microchips Micro scale Fluidic Applications

NANO COATINGS

Nanocoating materials -Carbon based nanostructure materials- vehicle weight reduction-aluminium alloy engine-polycarbonate window-scratch resistant-UV resistant and self healing car paints -interior-automotive paints-dirt resistant paints- Nano-coatings for engine application- vehicles windows and wipers-automotive textiles- nanoparticles fillers for tires

NANOSENSORS

Micro scale physical - temperature, acceleration, pressure, strain - chemical sensors - oxygen and hydrogen - Safety-Additional airbags and sensors-Satellite sensing modules-Roll over sensing-Occupant position– Occupant Classification Sensors -Tyre pressure monitoring sensor-Lane Departure Warning -Driver drowsiness monitor-Night vision –Comfort –Convenience - Passive authentication-Door handle operation-Power door closure sliding/lift –Anti-trap, position- Multizone HVAC Temperature and humidity

CHALLENGES AND OPPORTUNITIES

Improving fuel cell performance of future generations of hydrogen powered cars-flexible hydrogen sensors nanostructured materials- Improve fuel efficiency - polymer glazing-fuel cell-solar cell-electro chromatic layers-High performance automobile systems

Total hours to be taught : 45

Reference(s) :

1	Joao Paulo Carmo and Joao Eduardo Ribeiro, New Advances in Vehicular Technology and Automotive Engineering", ISBN 978-953-51-0698-2, Published: August 1, 2012
2	Yuwen Zhang ,Nanofluids: Research, Development and Applications, Nova Science Pub Inc (June 30, 2013)
3	Michael Berger.” Nanotechnology in the automotive industry” Copyright Nanowerk 2010

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Elective III						
Course Code	Course Name	Hours / Week			Credit	Maximum Marks
		L	T	P	C	CA
40 PNT E34	**ELECTROCHEMICAL ENERGY SOURCES**	3	0	0	3	50
Objective(s)	With the present development of battery technology, it is necessary to develop efficient energy storage system for the future trends. This course gives fundamental concepts for solving different kinds of problems that occur in energy storage system technology. At the end of the course the students would be acquainted with the basic concepts in all kind of batteries and their uses.					

INTRODUCTION

Basic concepts-Components & Classification of Cells and Batteries-Operation of a Cell- Theoretical Cell Voltage, Capacity, and Energy-Specific Energy and Energy Density of Practical Batteries-Factors affecting Battery Performance-Battery standardization-Battery design-General Characteristics-Selection and Application of Batteries.

PRIMARY BATTERIES

Classification of primary batteries-Cell components-Cell design-Performance characteristics of primary batteries-Zinc/carbon batteries-Magnesium and aluminium batteries -Zinc alkaline batteries-Zinc air batteries-Button configuration-Mercuric oxide batteries-silver oxide batteries-lithium primary batteries-Solid electrolyte batteries.

SECONDARY BATTERIES

General characterisation and application of secondary batteries-Types and characteristics of secondary batteries-Lead acid batteries-Valve regulated lead-acid batteries-Iron electrode batteries-Nickel cadmium batteries and its types-Nickel/zinc batteries-Zinc/carbon rechargeable batteries-Nickel metal hydride batteries-Lithium-Ion batteries-

RESERVE BATTERIES

Classification of reserve batteries-characteristics of reserve batteries-Magnesium water activated batteries-Zinc/silver oxide reserve batteries-Spin dependent reserve batteries-Ambient temperature lithium anode reserve batteries-Thermal batteries-Sodium-beta batteries-Battery design and application.

PORTABLE FUEL CELLS & SUPER CAPACITORS

Supercapacitors – characteristics- Types – Applications -Zinc-Aluminium-Magnesium-Lithium-air batteries-Fuel cells - General characteristics and Operation of the fuel cell-Innovative designs for low wattage fuel cells. Applicable fuel cell technologies - System requirements- Fuel processing & storage technologies-Hardware & performance.

Total hours to be taught : 45

Reference(s) :

1	Thomas Reddy, “Linden’s Handbook of Batteries”, McGraw Hill Professional, USA, 2010.
2	Ogumi Z, “Battery/Energy technology (General)”, The Electrochemical Society, USA 2010
3	Dudney N, “Metal/Air and Metal/Water Batteries”, The Electrochemical Society, USA 2010
4	Ronald M. Dell David A. J. Rand, “Understanding Batteries”, RSC, UK, 2001.

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Elective IV								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E41	**MICRO AND NANO ELECTRO MECHANICAL SYSTEMS**	3	0	0	3	50	50	100
Objective(s)	To explore the knowledge on MEMS Technology. To understand the principle, architecture, fabrication and application of MEMS. To study the properties of materials used for MEMS design. To explore the basic principle and fabrication and application of NEMS.							

INTRODUCTION

MEMS and Microsystems - MEMS and Microsystem Products - Microsystems and Microelectronics - Microsystem and Miniaturization-Microminiaturisation Process-Methods and Limitation of Microminiaturisation-Scaling – Milestone of Silicon Technology–Microelectronic and Mechanical Systems (MEMS) – Micromechanics Technology – Micromechanics for Nanoelectronics – Integrated Optoelectronics.

MICRO SYSTEMS FABRICATION

Silicon micromachining – Bulk Micromachining – Surface Micromachining - Microsystems Fabrication Techniques – Photolithography – Ion Implantation – Diffusion – Oxidation – CVD – PVD – sputtering – Epitaxy-Etching – LIGA – X-ray based fabrication – Packaging of Mems Devices–Microsystem Packaging–Packaging Technology – Sealing – 3D Packaging – Assembly of Micro System - Selection of Packaging Materials-Pressure Sensor Packaging.

MICROSYSTEM DESIGN

Design considerations – Process Design – Mechanical Design – Mechanical Designing Methods-Design of Silicon Die for Micro-Pressure Sensor-Design of Micro fluidic Network System – Computer Aided Designing

.

NANO ELECTROMECHANICAL SYSTEMS

Introduction – Nano Machining of NEMS - electron beam lithography – Nano electromechanical systems Fabrication – Nano Imprint Lithography – Polymeric Nano Fiber Templates – Focused Ion Beam - Wet Chemical Etching – Stencil Lithography and Sacrificial Etching – Large Scale Integration – Future Challenges – Applications.

APPLICATIONS OF MEMS AND NEMS

Micro sensors –Acoustic Wave Sensors-Biosensors-Chemical Sensors-Optical Sensors-Pressure Sensors-Thermol Sensors-Mems With Microactuators – Micro Accelerometers-Micro Fluidics – Gyroscope - Piezo Resistive – Capacitive - NanoRobotics – Micro Channel Heat Sinks – Visual Display – Precision Optical Platform – Optical Data switching – RF MEMS – MEMS variable capacitors – MEMS switches – Resonators

Total hours to be taught : 45

Reference(s) :

1	K. Goser, P. Glosekotter and J. Dienstuhl, “Nanoelectronics and Nanosystems - From Transistors to Molecular Quantum Devices” Springer, 2004.
2	Tai –Ran Hsu, “MEMS & Microsystems Design and Manufacture”, Tata McGraw-Hill publication, 2013.
3	P. Rai-Choudhury, “MEMS and MOEMS technology and applications”, PHI learning private Ltd, 2009.
4	Mohamed Gad-el-Hak, “The MEMS Handbook”, CRC Press, 2002.

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Elective IV								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E42	**NANOTECHNOLOGY IN CONSTRUCTIONS**	3	0	0	3	50	50	100
Objective(s)	To provide exposure to the students on nanotechnology in construction. To study the various materials used in construction, properties and application.							

INTRODUCTION

Nano construction – Nano bricks - Nano cements – Nano steels - Nano construction based on chemicals - Construction points based on nanotechnology

MATERIALS PROPERTIES

Materials **-** conventional materials Surfaces and coatings- Scratch resistance - Corrosion and UV resistance Thermal performance - potential energy-efficiency benefits – buildings structural materials

ENVIRONMENTAL IMPACTS

Corrosion resistance steels - Window coatings to prevent - Dirt build up - Lighting technology Anti –graffiti coatings and paints - Proprietary products in cement and concrete.

APPLICATIONS

Lighter and stronger - structural composites and low maintenance – coating Improving pipe joining - materials and techniques Better properties of cementitious – materials Reducing the thermal transfer rate of fire - retardant and insulation materials Increasing the sound absorption of acoustic – absorbers Increasing the reflectivity of glass.

CHALLENGES AND OPPORTUNITIES

Techniques for dispersing nanofillers - Measuring degree of dispersion - Measurement of adhesion and interfacial properties - Chemical and mechanical measurements at the nanoscale - Prediction of nanocomposite properties and service life over a wide range of length scales - Unknown health and environmental effects – virgin, released material.

Total hours to be taught : 45

Reference(s) :

1	http://www.azonano.com/article.aspx?ArticleID=3093
2	http://www.thenbs.com/topics/ConstructionProducts/articles/nanotechnologyInConstruction.asp
3	“Application of Nanotechnology in Construction”, *Materials and Structures*, **37,** 649 (2004).
4	http://www.nist.gov/tpo/upload/Nanotechnology_in_Building_and_Construction_Sampling_2.ppt

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Elective IV								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E43	**NANOTECHNOLOGY IN SEMICONDUCTOR DEVICES**	3	0	0	3	50	50	100
Objective(s)	Understand the basic about semiconducting properties of nanomaterials and impart the knowledge on the semiconductor basics. Impart knowledge about semiconductor nanodevices.							

SEMICONDUCTOR FUNDAMENTALS

Introduction to Semiconductor physics – Semiconductor nanostructures – Electronic structure and physical process – Principles of semiconductor nanostructures based electronic and electro-optical devices

QUANTUM CONFINED MATERIALS

Quantum dots – optical transitions – absorption-inter-band transitions-quantum confinement intra band transitions-fluorescence/ luminescence–photoluminescence - Fluorescence optically excited emission – electroluminescence emission.

SEMICONDUCTOR NANOPARTICLES

Optical luminescence and fluorescence from direct band gap semiconductor nanoparticles, surface-trap passivation in core-shell nanoparticles, carrier injection, polymer-nanoparticle, LED and solar cells, electroluminescence, barriers to nanoparticle lasers, doping nanoparticles, Mn-Zn-Se phosphors, light emission from indirect semiconductors, light emission form Si nanodots.

SEMICONDUCTOR NANOWIRES

Fabrication strategies, quantum conductance effects in semiconductor nanowires, porous Silicon, nanobelts, nanoribbons, nanosprings. Nano scale MOSFET.

SINGLE-ELECTRON NANODEVICES

Resonant Tunneling Transistor - Single-Electron Transistors; Single-Electron Dynamics; Nanorobotics and Nanomanipulation; Mechanical Molecular Nanodevices; Nanocomputers: Theoretical Models; Optical Fibers for Nanodevices; Photochemical Molecular Devices; DNA-Based Nanodevices; Gas-Based Nanodevices; Micro and Nanomechanics

Total hours to be taught : 45

Reference(s) :

1	Hari Singh Nalwa, “Encyclopedia of Nanotechnology”, USA 2011
2	Bharat Bhusan, “Springer Handbook of Nanotechnology”, springer, Newyork, 2007
3	Herve Rigneault, Jean-Michel Lourtioz, Claude Delalande, Ariel Levenson, “Nanophotonics”, john wiley & sons, 2010
4	K. Goser, P. Glosekotter and J. Dienstuhl, “Nanoelectronics and Nanosystems-From Transistors to Molecular Quantum Devices”, Springer, 2004.

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Elective IV								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E44	**RESEARCH METHODOLOGY - ENGINEERING AND MANAGEMENT STUDIES**	3	0	0	3	50	50	100
Objective(s)	To provide awareness in research methodology and engineering management.							

RESEARCH METHODOLOGY

Research methodology – definition, mathematical tools for analysis, Types of research, exploratory research, conclusive research, modeling research, algorithmic research, Research process- steps. Data collection methods- Primary data – observation method, personal interview, telephonic interview, mail survey, questionnaire design. Secondary data- internal sources of data, external sources of data.

SCALES AND MEASUREMENTS

Scales – measurement, Types of scale – Thurstone's Case V scale model, Osgood's Semantic Differential scale, Likert scale, Q- sort scale. Sampling methods- Probability sampling methods – simple random sampling with replacement, simple random sampling without replacement, stratified sampling, cluster sampling. Non-probability sampling method – convenience sampling, judgment sampling, quota sampling.

HYPOTHESES TESTING

Hypotheses testing – Testing of hypotheses concerning means (one mean and difference between two means -one tailed and two tailed tests), Concerning variance – one tailed Chi-square test.

SAMPLE TESTS

Nonparametric tests- One sample tests – one sample sign test, Kolmogorov-Smirnov test, run test for randomness, Two sample tests – Two sample sign test, Mann-Whitney U test, K-sample test – Kruskal Wallis test (H-Test)

ANALYSIS AND REPORT

Introduction to Disciminant analysis, Factor analysis, cluster analysis, multidimensional scaling, conjoint analysis. Report writing- Types of report, guidelines to review report, typing instructions, oral presentation

Total hours to be taught : 45

Reference(s):

1.	Kothari, C.R., Research Methodology –Methods and techniques, New Age Publications, New Delhi, 2009.
2.	Panneerselvam, R., Research Methodology, Prentice-Hall of India, New Delhi, 2004.

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Elective V								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E51	**NANOSAFETY AND ENVIRONMENTAL ISSUES**	3	0	0	3	50	50	100
Objective(s)	To provide exposure to the students on safety and environmental issues of nano science and technology. To explore the toxic effects of nanotechnology on human health and life, analyze the various issues on environmental effects and explore suitable remedial measures.							

INTRODUCTION

Identification of Nano - Specific Risks- Responding to the Challenge -Human health hazard – Risk reduction – Standards – Safety – transportation of NP– Emergency responders. Risk assessment –Environmental Impact – Predicting hazard – Materials Characterization. Risk Assessment related to nanotechnology – Environmental and policy making- Ecotoxicity measurement of Polychlirinated biphenyl and intermediates in their degradation

NANOTOXICOLOGY

Inhalation of nanomaterials – Overview. Introduction- Inhalation deposition and Pulmonary clearance of Insoluble Solids – Bio –persistence of Inhaled solid material. Systemic Translocation of inhaled Particles. Pulmonary effects of SWCNT- Pulmonary Inflammatory Responses to SWCNTs *In Vivo* - Interactions of pulmonary Inflammation with oxidative stress – Interactions of SWCNTs with Macrophages

EXPERIMENTAL ISSUES

Nanoparticle exposure and systematic cardiovascular effects – experimental data – respiratory particulate matter exposure and cardiovascular toxicity, Nanoparticles – Hypothesis and research approaches. SWCNT – Experimental data. Toxicity of polymeric nanoparticles with respect to their application as drug carriers. Particle exposure through the indoor air environment –Measurement of indoor of PM and experimental study.

ETHICS

Needs for regulations, training and education for health protection and environmental security of nanotechnologies – definitions and essence – general benefits – benefits for health and medical practice – potential risks – The approaches to assessment of exposure to the nanotechnology. Bioethics and legal aspects of potential health and environmental risks in nanotechnology – Legal regulatory considerations of nanotechnology.

CHALLENGES AND FUTURES

Nanotechnology – the frame of worker training, public education, and participation – Introduction – Nanotoxicity – Workers protection – International documents – protection of medical staff – Nurses education – Public information. Occupational risk assessment and management – focus on Nanomaterials.

Total hours to be taught : 45

Reference(s) :

1	P.P. Simeonova, N. Opopol and M.I. Luster, “Nanotechnology - Toxicological Issues and Environmental Safety”, Springer 2006.
2	Vinod Labhasetwar and Diandra L. Leslie, “Biomedical Applications of nanotechnology”, A John Willy & son Inc,NJ, USA, 2007 .
3	Miyawaki, J.; *et.al* Toxicity of Single-Walled Carbon Nanohorns. *ACS Nano 2* (213–226) 2008.
4	Hutchison, J. E. Green Nanoscience: A Proactive Approach to Advancing Applications and Reducing Implications of Nanotechnology. *ACS Nano 2*, (395–402) 2008.
5	Mo-Tao Zhu *et.al* Comparative study of pulmonary responses to nano- and submicron-sized ferric oxide in rats Toxicology, 21 (102-111) 2008.
6	Dracy J. Gentleman, Nano and Environment: Boon or Bane? Environmental Science and technology, *43* (5), P1239, 2009.

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Elective V								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E52	**INTELLECTUAL PROPERTY RIGHTS**	3	0	0	3	50	50	100
Objective(s)	To provide awareness about IP Rights. To provide exposure to protect the Intellectual property.							

IMPORTANCE OF INTELLECTUAL PROPERTY RIGHTS

Introduction – Tangible and Intangible Properties- Intellectual property- an intangible wealth and a product of creative mind – IPR and its significance- Types of IPRs

COPYRIGHTS AND RELATED ISSUSES

Works protected by copyright- Reproduction rights-moral rights-translation and adaptation rights-copyright issues-Piracy- civil -criminal remedies-Infringement- Patents – Copyrights of designs and related rights – Trade Marks and rights arising from Trademark registration – Definitions – Industrial Designs and Integrated circuits – Protection of Geographical Indications at national and International levels – Application Procedures

INTERNATIONAL AGREEMENT FOR THE PROTECTION OF IPR

Berne convention-Madrid agreement-Hague agreement-Patent cooperation treaty-Paris convention-Lisbon Agreement - Establishment of WIPO – UPOV and WTO-Mission and Activities – History – General Agreement on Trade and Tariff (GATT)-

PATENTED INVENTION AND ADMINISTRATION

Significance of Patent information-classification of invention according to technology- Novelty search and state of art search-Indian Position Vs WTO and Strategies – Indian IPR legislations – commitments to WTO-Patent Ordinance and the Bill – Draft of a national Intellectual Property Policy – Present against unfair competition80

APPLICATIONS

Case Studies on – Patents (Basumati rice- turmeric- Neem- etc-) – Copyright and related rights – Trade Marks – Industrial design and Integrated circuits – Geographic indications – Protection against unfair competition- Patent agents-Examiner of Patents- IPR Managers-

Total hours to be taught : 45

Reference(s) :

1	Prabuddha Ganguli, “Intellectual Property Rights,”TMH, 2001.
2	Subbaram N-R- “ Handbook of Indian Patent Law and Practice “- S- Viswanathan (Printers and Publishers) Pvt- Ltd—1998.
3	Richard Stim, “Intellectual Property Copyrights, trademarks, and Patents,” Cengage Learning India Private Ltd, 2004.
4	Deborah E. Bouchoux, “Intellectual Property Rights,” Cengage Learning India Private Ltd, 2005.
5	Dr.Radhakrishnan & Balasubramani” IPR
6	Eli Whitney- United States Patent Number : 72X- Cotton Gin- March 14- 1794
7	Intellectual Property Today : Volume 8- No- 5- May 2001

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Elective V								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E53	**PRODUCT DESIGN, MANAGEMENT AND ENTREPRENEURSHIP**	3	0	0	3	50	50	100
Objective(s)	To study the principle behind the technology development and market demand and to impart the basic knowledge on product development .To understand the various process techniques available for cost- effective manufacturing. To Impart the knowledge on management technique and entrepreneurial competence & environment.							

PRODUCT DESIGN

Concept generation- Product Architecture- Industrial Design Process- Management of Industrial design Process and Assessing the quality of Industrial Design - Establishing the product specification.

PRODUCT DEVELOPMENT

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

MANAGEMENT TECHNIQUES

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

ENTREPRENEURIAL COMPETENCE & ENVIRONMENT

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

MANAGEMENT OF SMALL BUSINESS

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

Total hours to be taught : 45

Reference(s) :

1	Karal, T.Ulrich Steven, D.Eppinger, “Product Design and Development”, McGraw- Hill International, editions, 2003.
2	S.Rosenthal, “Effective Product Design and Development”, Irwin, 1992.
3	H.Koontz and H.Weihrich, “Essentials of management”, McGraw Hill Publishing company, Singapore international edition, 1980.
4	J.J.Massie, “Essentials of Management” Prentice Hall of India Pvt. Ltd., 1985.-76712-3.
5	Hisrich, “Entrepreneurship” Tata Mc Grew Hill, New Delhi.

K.S.Rangasamy College of Technology - Autonomous Regulation								R 2014
Department	Nano Science and Technology	Programme Code & Name	PNT : M.Tech – Nano Science and Technology					
Elective V								
Course Code	Course Name	Hours / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ES	Total
40 PNT E54	**RESEARCH METHODOLOGY - SCIENCE AND HUMANITIES**	3	0	0	3	50	50	100
Objectives	To provide awareness in research methodology onscience and humanities.							

RESEARCH METHODOLOGY

Research Methods Versus Methodology-Objectives of Research-Types of Research-Research Approaches-Criteria of Good Research- Hypothesisation-Selection of Topic

DATA COLLECTION & COMPILING

Collection of Primary Data-Collection of Secondary Data-Interview method-Compiling a Working Bibliography-Evaluating Sources

MECHANICS OF WRITING

Spelling-Punctuation-Abbreviations-Margins and Spacing – Heading and Title-Page Numbers-Corrections and Insertions

DOCUMENTATION

Preparing the list of works cited - Citing Sources in the text- Endnotes and footnotes-Parenthetical References.

PLAGIARISM

Definition – Forms of Plagiarism – Consequences of Plagiarism- Unintentional Plagiarism-Copyright Infringement-Collaborative work

Total hours to be taught : 45

Reference(s):

1.	Joseph Gibaldi, “MLA Handbook for Writers of Research Papers’, Modern Language Association of America, 2009
2.	Wayne Goddard and Stuart Melville, “Research Methodology – An Introduction’, Juta and Company Ltd, 2004
3.	Ranjit Kumar, “Research Methodology”, Sage Publications, 1999.