SEMESTER I

15LN01 COMPUTATIONAL MATHEMATICS

2 2 0 3

I**NTRODUCTION TO COMPUTATIONAL METHODS:** Solving sets of equations -Gauss elimination method, LU-Choleski method, Gauss Jacobi method, Gauss Siedel method, successive over relaxation method, system of non-linear equations – Newton's method. (6+6)

INTERPOLATION: (Revision – Forward, Backward, divided difference interpolation) - Cubic spline interpolation, Bezier curves and B-spline curves, polynomial approximation of surfaces, least square approximations. (4+4)

NUMERICAL INTEGRATION: Numerical integration - Gaussian quadrature, trapezoidal rule and Simpson's one third rule, multiple integrals, multiple integration with variable limits, application of cubic splines. (4+4)

NUMERCIAL SOLUTION OF ODE: Taylor series method, Euler and modified Euler method (Heun's method), Runge Kutta method, Milne's method, Adams - Moulton method. (3+3)

NUMERICAL SOLUTION OF PDE: Classification of partial differential equations of second order, Liebmann's method for Laplace equation and Poisson equation, explicit method and Crank-Nicolson method for parabolic equations, explicit method for hyperbolic equations. (4+4)

FINITE ELEMENT METHOD: The Rayleigh-Ritz method, collocation and Galerkin method, finite element method – ordinary differential equations, elliptic, parabolic, hyperbolic partial differential equations. (6+6)

SIMULATION MODELING: Introduction, simulating deterministic behavior, area under a curve, generating random numbers, simulating probabilistic behavior, inventory model: gasoline and consumer demand. (3+3)

Note: Exposure to software. Design problems can be given to the students and they have to submit assignments / term papers using programs.

Total L: 30+T: 30 = 60

REFERENCES:

1. Curtis F, Gerald and Patrick O Wheatly, "Applied Numerical Analysis", Pearson Education, New Delhi, 2011.
2. Steven C Chapra and Raymond P Canale, "Numerical Methods for Engineers with software and Programming Applications", Tata McGraw Hill, New Delhi. 2006.
3. John H Mathews and Kurtis D Fink, "Numerical Methods using MATLAB", Prentice Hall, New Delhi. 2004,
4. Douglas J Faires and Riched Burden, "Numerical Methods", Cengage Learning, New Delhi, 2005,
5. Ward Cheney and David Kincaid, "Numerical Mathematics and Computing", Cengage Learning, New Delhi, 2013.

15LN02 FUNDAMENTALS OF NANOSCIENCE

4 0 0 4

NANO INNOVATIONS: Scientific evolution - Feynman's quantum electrodynamics – Taniguchi's nanotechnology – Drexler's engines of creation - Kroto-Curl-Smelly's Buckminster fullerene - Binnig-Rohrer's tunnelling electrons – Eigler's manipulation of atom – Ijima's caban nano tubes – Dekker's SET - Time and length scale in structures – Drexler–Smalley debate on molecular nanotechnology - Definition of a nanosystem – Nanotechnology Initiatives – challenges and future prospective of nanoscience. (12)

FORCES AND BONDS: intermolecular and intra-molecular forces –Covalent and coulomb interactions – Electrostatic stabilization - surface charge density - electric potential at the proximity of solid surface - van der Waals forces - Dipole-dipole interactions.– Repulsive forces – Special Interactions – Hydrophobic, and Hydrophilic interactions, super-hydrophophicity, Bonds: Atomic structure - Chemical bonds– Ionic interactions –Covalent bonds – Metal bonds – Hydrogen bonds (12)

NANO DIMENSIONAL SYSTEM: artificial atomic clusters Size effect on electronic Properties – Magic Numbers - nanowires, nanotubes, nanostructured beams, and nanocomposites - Nanorods, Nanocones, Nanotetrapods, Nanoparticles, Nanocombs ,Nanowalls, Nanoislands, Nanoflowers, Nanobrushes, Nanotowers and Nanocastles, Quantum Dots size dependent absorption spectra - phonons in nanostructures. Size Effect on electron – phonon coupling. (12)

TRANSPORT IN NANOSTRUCTURE: Evolution of band structures and Fermi surface –Dimensionality and size dependent phenomena – Fraction of surface atoms – Surface energy and surface stress – quantum-size-effect (QSE) - Local density of states - Ballistic transport - Coulomb blockade - nano-scale magnets, superparamagnetism, Size-induced metal-insulator-transition (SIMIT)-electron transport and kinetics in Zero, one and two dimensional nanostructures (12)

SPECIAL NANOSYSTEMS: Diffusion in Nanomaterials, Nanoscale heat Transfer; catalysis by gold nanoparticles; transition metal atoms on Nanocarbon Surfaces; molecular structure of fullerene, carbon nano tube, graphene and nano diamonds, Electrical,

Optical, Mechanical, and Vibrational properties of carbon allotropes, Applications and Functionalization of CNT, upcoming functional nanosystems, nanobots. (12)

Total L: 60

REFERENCES:

1. Pradeep T, "Nano: The Essentials Understanding Nanoscience and Nanotechnology", Tata Mc-Graw Hill, New Delhi, 2012.
2. Masaru Kuno, "Introductory Nanoscience: Physical and Chemical Concepts", Taylor And Francis, New York, 2012.
3. Hornyak G L, Tibbals H F and Dutta J, "Introduction to Nanoscience and Nanotechnology", CRC Press, London, 2009.
4. Brenner D W, Lyshevski S E, and Goddard W A, "Handbook of Nanoscience Engineering and Technology", CRC Press, 2009.
5. Ramachandra Rao M S and Shubra Singh, "Nanoscience and Nanotechnology: Fundamentals to Frontiers", Wiley, Delhi, 2014.

15LN03 QUANTUM MECHANICS

4 0 0 4

ORIGIN OF QUANTUM MECHANICS: Limitation of classical physics - Planck's quantum hypothesis - Einstein's photoelectric effect - wave nature of particle - uncertainty principle - Schrödinger's time dependent and independent wave equations - particle in a box - harmonic oscillator - rigid rotator. (12)

FORMALISM: Postulates of quantum mechanics - simultaneous measurability of observable - equations in motion - linear harmonic oscillator - operator method - particle moving in a spherically symmetric potential - hydrogen atom - hydrogen orbital - matrix representation of wave functions. (12)

OPERATORS: Linear operator - hermitian operator - angular momentum operators - eigen values and eigen functions of L^2 and L_Z - eigen values of J^2 and J_Z - spin angular momentum - addition of angular momenta - clebsch - gordan coefficients - computations. (12)

VARIATION & PERTURBATION: Variational principle - variation method for excited states - ground state of helium, hydrogen molecule - deuteron - first order perturbation - harmonic perturbation - transition to continuous states. (12)

RELATIVISTIC WAVE EQUATIONS: Klein - gordon equation - particle in a coulomb field - Dirac's equation for a free particle - plane wave solution - negative energy states - magnetic moment of the electron - radial equations for an electron in a general potential - many electron atoms - Hatree and Hatree - fock equation. (12)

Total L: 60

REFERENCES:

1. Aruldhas G, "Quantum Mechanics", PHI Learning Pvt. Ltd., New Delhi. 2011.
2. Mathews P M and Venkatesan K, "A Text book of Quantum Mechanics", Tata McGraw Hill, New Delhi, 2007.
3. Dirac P A M, "Principles of Quantum Mechanics", Oxford University Press, New Delhi, 2006.
4. Edward L Wolf, "Quantum Nanoelectronics", Wiley Vch Verlag GmbH & Co, Weinheim, 2009.
5. Eisberg R, and Resnick R. "Quantum Physics of Atoms, Molecules, Solids", Nuclei and Particles, Wiley-India (P) Ltd., 2007.

15LN04 SYNTHESIS OF NANOMATERIALS

3 0 0 3

PHYSICAL INORGANIC CHEMISTRY: Acidity – basicity and pK_a – measurement of acid & base strength – chemical salts – chemical oxides – conductivity 515lasmon515rs of solids and liquids, dissociation of salts, oxides and alkali in water, stabilization agents – types of stabilization – coagulation – aggregation, functional groups-nucleation-growth.
(9)

SELF ASSEMBLY: Self assembly – classification of self assembly process, Self Assembled Monolayer (SAMs), Langmuir Blodgett (LB) films – micelle formation clusters – biomimetic approaches – biomineralization of marine organism – liposomes. (9)

POLYMER CHEMISTRY AND FORCES AT NANOSCALE: Polymerization – classes of polymers –polydispersity index- types of polymerization – emulsion polymerization – condensation polymerization – addition polymerization –living polymerization, Van der Waals force – columbic force – steric force –solvation force-hydrogen bonding. (9)

SYNTHESIS METHODOLOGY PART- I: Sol-gel processing – mechanical alloying and milling – Inert gas condensation technique – clusters-chemical 515lasmo deposition- physical 515lasmo deposition- colloids – molecular beam epitaxy – atomic layer deposition – magnetron sputtering – RF sputtering-pulsed layer deposition.-electro deposition-spray pyrolysis-vapor and solution based growth of nanowire-synthesis of single walled and aligned carbon nanotube. (9)

OXIDE NANOPARTICLES: magnetite particles in nature-preparation of isolated nanoparticles, hydrolysis, oxidation, thermolysis, metathesis, solvothermal methods. (9)

Total L: 45

REFERENCES:

1. Rao C N R, Muller A and Cheetham A K, "The Chemistry of Nanomaterials Synthesis, Properties and Applications", Wiley-VCH, Germany, 2006.
2. Nalwa H S, "Encyclopedia of Nanoscience and Nanotechnology", American scientific, New York, 2004.
3. Cao G, "Nanostructures and Nanomaterials: Synthesis, Properties and Applications", World Scientific Publishing, Singapore, 2011.
4. Pradeep T, "Nano: The essentials, Understanding Nanoscience and Nanotechnology", Tata Mc Graw Hill, New Delhi, 2007.
5. Vikas Mittal, "Characterization Techniques for Polymer Nanocomposites", Wiley-VCH, Germany, 2012.

15LN05 MATERIALS SCIENCE

3 0 0 3

STRUCTURE OF CRYSTALLINE SOLIDS: Atomic bonding – crystalline state of solids-Crystal structure – Unit cell – Bravais Lattice-Crystal systems-Lattice parameters-Crystallographic planes and directions- Miller Indices- Anisotropy- Non-crystalline solids, Diffraction of X-rays by simple space lattice- Bragg's law- Experimental methods of X-ray diffraction- Diffraction of electrons of crystals- Diffraction of neutrons of crystals. Crystal imperfections. (9)

ELECTRICAL PROPERTIES: Free electron theory – Fermi Dirac distribution- Density of States- Sommerfeld's theory of electrical conductivity- Band theory of solids- Kronig Penny model – Motion of electron in one dimension – Brillouin zones- Band model for metals, semiconductors and insulators. Dielectric properties: static dielectric constant – Complex dielectric constant- Dielectric losses and relaxation time- Classical theory of electronic polarization ferroelectrics and piezoelectrics: Classification and properties of ferroelectrics- Ferroelectric domains-Piezoelectric materials and applications. (9)

SEMICONDUCTORS: Lattice properties of the elements of the fourth group- Models for an impurity semiconductor- Electronic degeneracy in semiconductors- Carrier concentration in intrinsic and extrinsic semiconductors- Fermi level- Variation of conductivity and mobility with temperature- Conductivity and Hall effect with a single type of charge carrier- Mobility and Hall effect determined by different scattering processes-Constant energy surfaces and effective mass in silicon and Germanium- Lifetime and diffusivity of minority carriers. (9)

MAGNETICMATERIALS: Origin of magnetism-Types of magnetic materials- ferromagnetism- Domain theory- Magnetic hysteresis-Weiss molecular field theory-Heisenberg's theory- Magnetic anisotropy- Domain walls – Exchange energy – Antiferromagnetism – Ferrites: Structure and properties. Superconductors – London equation- Josephson effect – electronic specific heat in superconducting state- Meissner effect-Type I and II superconductors-SQUID. (9)

OPTICAL AND THERMAL 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. – Einstein's theory of specific heat- Debye theory- Elastic waves in an infinite 1D array of identical atoms- vibrational modes of a finite 1D lattice of identical atoms – Specific heat of 1D lattice identical atoms – Vibrational modes of diatomic linear lattice- Vibrational spectra and specific heat of 3D lattices. (9)

Total L: 45

REFERENCES:

1 Callister W D, "Materials Science and Engineering", Wiley Publications, 2010.
2 Charles Kittel, "Introduction to Solid State Physics", Wiley India P. Ltd., 2013.
3 Dekker A J, "Solid State Physics", Macmillan Publications, 2012.
4 James F Shackelford, "Introduction to Materials Science for Engineers", Prentice Hall, 2008.
5 Michael Shur, "Physics of Semiconductor Devices", Prentice Hall, 1995.
6 Pillai S O, "Solid State Physics, New Age International", 2005.

15DN51 SYNTHESIS OF NANOMATERIALS LABORATORY

0 0 4 2

1. Nanofibers – Electro spinning
2. Preparation of metal nanoparticles – chemical reduction method
3. Synthesis of ceramic nanoparticle
4. Fabrication of nanofilms-chemical method
5. Surface Plasmon absorbance of metal nanoparticles – UV Vis spectroscopy
6. Imaging of nanofibre – AFM
8. Synthesis of metaloxide nanoparticle.
9. Measurement of resistance using Omnicant

Total P: 60

15LN61 INDUSTRIAL VISIT & TECHNICAL SEMINAR

1 0 2 2

The student will make at least two technical presentations on current topics related to the specialization. The same will be assessed by a committee appointed by the department. The students are expected to submit a report at the end of the semester covering the various aspects of his/her presentation together with the observation in industry visits. A quiz covering the above will be held at the end of the semester.

Total L: 15 + P: 30 = 45

SEMESTER II

15LN06 CHARACTERIZATION OF NANOMATERIALS

2 2 0 3

ABSORPTION AND EMISSION SPECTROSCOPY: Nature of electromagnetic radiation-electromagnetic spectrum-atomic energy levels-molecular electronic energy levels-vibrational energy levels-Raman effect-Nuclear spin behavior-electron spin behavior-X-ray energy levels , UV-Visible Spectroscopy - Atomic Absorption Spectroscopy (AAS), Fluorescence spectroscopy. (6+6)

SURFACE ANALYSIS: Introduction-instrumentation-specimen preparation-imaging modes of Optical microscopy, scanning electron microscopy , transmission electron microscopy ,atomic force microscopy ,scanning tunneling microscopy , near field optical scanning microscopy, secondary ion mass spectroscopy-Gas chromatography mass spectroscopy-photon correlation spectroscopy. (6+6)

MOLECULAR ANALYSIS: Infra red spectrometry-correlation of infrared spectra with molecular structure-instrumentation-sample handling-quantative analysis-Fourier transform Infrared spectroscopy- Raman spectroscopy-Instrumentation-sample handling and illumination-structural analysis-quantative analysis-comparision of raman with IR spectroscopy, Nuclear Magnetic Resonance Spectroscopy-continuous wave NMR-pulsed Fourier transform NMR-Spectra and molecular Structure-Elucidation of NMR spectra. (6+6)

ELEMENTAL ANALYSIS: X-ray methods-production of X-rays and X-ray spectra-instrumentation-Direct X-ray method-X-ray absorption methods-X-ray fluorescence method-X-ray diffraction-Auger emission spectra-Electron spectroscopy for chemical analysis- X-ray photoelectron spectroscopy. (6+6)

THERMAL ANALYSIS AND MECHANICAL ANALYSIS: differential scanning calorimetry –thermogravimetric method-evolved gas detection and analysis-differential thermal analysis-thermomechanical analysis-dynamic mechanical analysis - micro hardness - nanoindendation - nanotribology, nanotribometre, surface force apparatus, quartz crystal microbalance-Friction force microscopy. (6+6)

Total L: 30+T: 30 = 60

REFERENCES:

1. Willard, “Instrumental Methods of Analysis”, Van Nostrand, 2000.
2. Gaponenko S V, “Optical Properties of semiconductor Nanocrystals”, Cambridge University Press, 1998.
3. Goddard W, “Handbook of NanoScience, Engineering and Technology”, CRC Press, 2007.
4. Cao G., “Nanostructures and Nanomaterials: Synthesis, Properties and Applications”, Imperial College Press, 2004.
5. Yang leng, “Materials Characterization: Introduction to Microscopic and Spectroscopic Methods”, Wiley, 2013.

15LN07 NANOLITHOGRAPHY

3 0 0 3

PATTERNING OF THIN FILMS: Introduction - Necessity for a clean room , different types of clean rooms , construction and maintenance of a clean room- Lithography - Optical lithography, Optical projection lithography- Photo mask - Photomask fabrication, Photomask inspection, defects and repair- Resist for nanolithography. (9)

RESOLUTION ENHANCEMENT TECHNIQUES: Phase shift mask - Attenuated phase shift masks - alternating phase shift masks - Off axis illumination - Optical proximity correction - Sub resolution assist feature enhancement - Optical immersion lithography - Zone plate array lithography. (9)

ELECTRON BEAM LITHOGRAPHY: Scanning electron beam lithography - maskless EBL - Scattering with angular limitation projection e-beam lithography (SCALPEL) - Projection reduction exposure with variable axis immersion lenses (PREVAIL). (9)

ADVANCED LITHOGRAPHIC TECHNIQUES: X-ray lithography, Ion beam lithography - Focused ion beam lithography , Masked ion beam lithography, Masked ion beam direct structuring- Extreme ultraviolent lithography-Dip pen lithography. (9)

SOFT LITHOGRAPHY AND ETCHING: Replica molding-microtransfer molding-micromolding in capillaries-UV molding-step and flash impring lithography **-** Nanoimprint lithography (NIL) - Solvent assisted micromolding - microcontact printing-nanotransfer printing. (9)

Total L: 45

REFERENCES:

1. Sami Franssila, "Introduction to Microfabrication", John Wiley & Sons, London, 2010.
2. Harry J Levinson, "Principles of Lithography", SPIE, New Jersey, 2005.
3. Chris A Mack, "Fundamental Principles of Optical Lithography the Science of Microfabrication", John Wiley & sons, London, 2007.
4. Nalwa H S, "Encyclopedia of Nanoscience and Nanotechnology", American scientific, 2004.
5. Alfred Kwok Kit Wong, "Resolution Enhancement Techniques in Optical Lithography", SPIE, Washington, 2001.

15LN08 MICRO AND NANO ELECTRO MECHANICAL SYSTEMS

3 0 0 3

INTRODUCTION AND SCALING: MEMS and microsystems - development of MEMS technology- MEMS future and applications, microsystems and microelectronics - MEMS challenges - scaling - scaling in geometry, rigid body dynamics, electrostatic forces, electromagnetic forces, electricity, fluid mechanics, heat transfer. (7)

MATERIALS FOR MEMS: Introduction - substrates and wafer- silicon substrate - crystal structure, miller indices, properties - silicon compounds - silicon dioxide, silicon carbide, silicon nitride, polycrystalline silicon- gallium arsenide - quartz- piezoelectric crystals - polymers - polymers for MEMS, conductive polymers. (7)

FABRICATION PROCESS: Physical Vapour Deposition (PVD) - evaporation, sputtering - Chemical Vapour Deposition (CVD) - etching process - wet chemical etching, plasma etching, Ion milling - patterning - lithography, lift off process - wafer bonding - silicon fusion bonding, anodic bonding- annealing- chemical mechanical polishing - doping - diffusion, implant. (12)

MEMS TECHNOLOGIES AND PACKAGING: Bulk micromachining - Isotropic and anisotropic etching, wet etchants, etch stop, dry etching, comparison of wet and dry etching - surface micromachining - Introduction, process, associated problems - LIGA Process and electroplating - Integration of electronics and MEMS technology- packaging - post fabrication process, package selection, die attach, Wire bond and Sealing. (12)

NEMS TECHNIQUES AND APPLICATIONS: Introduction to NEMS and its architecture - carbon nanotube electronics - modeling - introduction, analysis and simulation - simulation of Actuators, FET, Pressure transducer - applications and future challenges. (7)

Total L: 45

REFERENCES:

1. James J Allen, "Micro Electro Mechanical System Design CRC Press-Taylor & Francis", New York, 2005.
2. Tai Ran Hsu, "MEMS and Microsystems, Design, Manufacture and Nanoscale Engineering", John Wiley & Sons, New Jersey. 2008,
3. Syergey Edward Lyshevski, "MEMS and NEMS systems, Devices and Structures", CRC Press, New York, 2002.
4. Ananthasuresh G. K, Vinoy. K.J , Gopalakrishnan.S, "Micro and Smart Systems", Wiley India Pvt Ltd, New Delhi, 2012.
5. Vijay K. Varadan, Vinoy. K.J , Gopalakrishnan.S, "Smart material Systems and MEMS: Design and Development Methodologies", John Wiley & Sons, New York, 2011.

15LN09 NANOELECTRONICS

3 0 0 3

BASICS OF NANOELECTRONICS – Capabilities of nano electronics - physical fundamentals of nano electronics:Scaling principles,limits to scaling,power constrained scaling limits - basics of information theory - basics of lithographic techniques for nanoelectronics. (6)

LIMITING EFFECTS - Replacement Technologies - Energy and Heat dissipation - Parameter spread as Limiting Effect - Limits due to thermal particle motion - Reliability as limiting factor - Final objectives of integrated chip and systems. (7)

QUANTUM ELECTRON DEVICES - from classical to quantum physics: upcoming electronic devices - electrons in mesoscopic structure - short channel MOS transistor - split gate transistor - electron wave transistor - electron spin transistor - quantum cellular automate - quantum dot array. Principles of Single Electron Transistor (SET) - SET circuit design - comparison between FET and SET circuit design. (11)

NANOELECTRONICS WITH TUNNELING DEVICES- tunneling element technology - RTD: circuit design based RTD , Nano structured LEDs, photo detectors. Superconducting devices: Macroscopic characteristics, macroscopic model, super conducting switching devices, memory cells, flux quantum devices - application of Superconducting devices. Molecular electronics - Nano tubes and fullerene based switches, elementary circuits. (10)

MEMORY DEVICES AND SENSORS - Nano ferroelectrics - Ferroelectric random access memory - Fe-RAM circuit design - ferroelectric thin film properties and integration - calorimetric sensors - electrochemical cells - surface and bulk acoustic devices - gas sensitive FETs - resistive semiconductor gas sensors -electronic noses - identification of hazardous solvents and gases - semiconductor sensor array. (11)

Total L: 45

REFERENCES:

1. Rainer Waser, "Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel and Devices", Wiley Vch Verlag, Weiheim, 2005.
2. Shunri Oda and David Ferry, "Silicon Nanoelectronics", CRC Press, New York, 2005.
3. Karl Goser, Peter Glosekotter and Jan Dienstuhl, "Nanoelectronics and Nanosystems", Springer, New Jersey, 2004.
4. Mick Wilson, Kamali Kannangara, Geoff Smith Michelle Simmons, Burkhard Raguse, Nanotechnology: Basic Science and Emerging technologies, Overseas Press India Pvt.Ltd.,2005.
5. George W. Hanson, "Fundamentals of Nanoelectronics", Pearson, New Delhi, 2009.

15LN10 NANOSENSORS AND DEVICES

3 0 0 3

SENSOR CHARACTERISTICS : Active and passive sensors - static characteristic - accuracy, error, precision, resolution, sensitivity, selectivity, noise, drift, detection limit - reproducibility, hysteresis, stability, response time, recovery time, dynamic range - dynamic characteristics - zero order, first and second order sensors. (9)

TRANSDUCTION PRINCIPLES: Photoelectric effect - photo dielectric effect - photoluminescence effect - electroluminescence effect - chemiluminescence effect - Doppler effect - Barkhausen effect - Hal effect - Ettinshausen effect - thermoelectric effect - peizoresistive effect – piezoelectric effect - pyroelectric effect -Magneto-mechanical effect (magnetostriction) - Magneto resistive effect. (9)

INORGANIC SENSORS: Density of states (DOS) - DOS of 3D, 2D, 1D and 0D materials - gas sensing with nanostructured thin films - absorption on surfaces, metal oxide modifications by additives, surface modifications- Nano optical sensors- Nano mechanical sensors- Magnetically engineered spintronic sensors. (9)

ORGANIC SENSORS: Surface interactions-covalent coupling,adsorption,physical entrapment,chemical entrapment - using protein in nanodevices - antibodies in sensing - antibody in nano particle conjugates - enzymes in sensing - enzyme nanoparticles hybrid sensors - transmembrane sensors. Nanosensor based on Nucleotides and DNA - DNA decoders and microarrays - DNA protein conjugate based sensors- DNA sequencing with nanopores- Sensors based on molecules with dendritic architectures. (9)

APPLICATIONS: Cantilever sensors for diagnosis of diabetes mellitus and cancer- Nanotube based sensors for DNA detection and capnography- Nanowire based electrical detection of single viruses and biomolecules - ultrasensitive detection of pathogenic biomarkers and single bacteria. (9)

Total L: 45

REFERENCES:

1. Kourosh Kalantar – Zadeh & Benjamin Fry, "Nanotechnology- Enabled Sensors", Springer, New York, 2010.
2. Rajmohan Joshi, "Biosensor", Isha Books, New Delhi, 2006.
3. Brain R. Eggins, "Chemical Sensors and biosensors", John-Wiley, New York, 2002.
4. Bassi.A.S and Knopf.G.K, "Smart Biosensor Technology", CRC Press, New York, 2007.
5. Vijay K. Varadan, Linfeng Chen and Sivathanupillai, "Nanotechnology Engineering in Nano and Biomedicine", John Wiley, Canada, 2011.

15LN52 NANOFABRICATION LABORATORY

0 0 4 2

1. Fabrication of nanograin thin film capacitors by magnetron sputtering and characterization
2. Fabrication of nanograin thin film resistors
3. Fabrication of nanocomposite sensors and characterization
4. Preparation of CdS nanoparticles in polymer matrix for sensor applications
5. Preparation of CIGS thin films solar cells with nanostructure GaZnO
6. Laser micromachining and surface analysis for MEMS applications
7. Synthesis of nanostructure thin film sensors by spin coating
8. Synthesis of nano crystals for phosphor applications
9. Biotemplating
10. Nanoimprinting techniques.
11. 3D screen printing techniques.

Total P: 60

III SEMESTER

15LN71 PROJECT WORK – I

0 0 6 3

- Identification of a real life problem
- Developing a mathematical method for solving the above problem
- Finalisation of system requirements and specification
- Proposing different solutions for the problem based on literature survey
- Future trends in providing alternate solutions
- Consolidated report preparation of the above

15LN53 NANODEVICE DESIGN LABORATORY

0 0 4 2

1. Study of the simulation tool and device design optimization techniques
2. Design and simulation of nanowire / needle for biomedical applications
3. Design and simulation of cantilever for biomedical applications
4. Design and simulation of gyroscope
5. Design and simulation of accelerometer
6. Design and simulation of microfluidic channel for biomedical application
7. Simulation and optimization of porosity in hard tissues
8. Design and simulation of meniscal scaffold
9. Design and simulation of MEMS Microphone
10. Design and simulation of micromixer
11. Design of micromirror for optical applications

Total P: 60

IV SEMESTER
15LN72 PROJECT WORK- II

0 0 28 14

The project involves the following:

Preparing a project - brief proposal including

- Problem Identification in nanotechnology
- A statement of nanoscale system / process specifications proposed to be developed
- List of possible solutions including alternatives and constraints in nanotechnology
- Cost benefit analysis
- Time Line of activities

A report highlighting the problem finalization [based on functional requirements & standards (if any)]

A presentation including the following:

- Implementation Phase
- Testing & Validation of the developed nanoscale system
- Learning in the Project
- Consolidated report preparation

ELECTIVE THEORY COURSES

15LN21 NANOPHOTONICS

3 0 0 3

SEMICONDUCTOR QDS : Optical luminescence and fluorescence from direct bandgap semiconductor nanoparticles, surface-trap passivation in core-shell nanoparticles, carrier injection, polymer-nanoparticle LEDs and solar cells, electroluminescence; barriers to nanoparticle lasers; Mn-ZnSe phosphors; light emission from indirect semiconductors and Si nanodots. (9)

LINEAR AND NONLINEAR PHOTONICS: Maxwell's Equations, Photonic Band Gap and Localized Defect States, Transmission Spectra, Nonlinear Optics in Linear Photonic Crystals, Guided Modes in Photonic Crystals Slab- 1-D Quasi Phase Matching, Nonlinear Photonic Crystal Analysis, Applications of Nonlinear Photonic Crystals Materials and Devices,: $LiNbO_3$, Chalcogenide, Wavelength Converters. (9)

PLASMONICS: Introduction: Plasmonics, merging photonics and electronics at nanoscale dimensions, single photon transistor using surface plasmon, nanowire surface plasmons-interaction with matter, single emitter as saturable mirror, photon correlation, and integrated systems. (9)

NANOSTRUCTURE PHOTONICS: Surface Structures - Random Surfaces - Controlled Random Surfaces - Black Silicon, Thin Film Structures and Optical Coatings, Photonic Crystals, Optical Properties of Materials Including Quantum Structures - Frequency Conversion - Charge Carrier Generation - Multiple Exciton Generation - Optical Properties of Thin Films and Quantum Dots, Nanoplasmonics. (9)

APPLICATIONS: optical modulation by plasmonic excitation of quantum dots, Channel plasmon-polariton guiding by sub wavelength metal grooves, Near-field photonics: surface plasmon polaritons and localized surface plasmons, Slow guided surface plasmons at telecom frequencies, Graphene photonics and optoelectronics. (9)

Total L: 45

REFERENCES:

1. Shalaev V M and Kawata S, “Nanophotonics with Surface Plasmons”, Elsevier Science Publishing, Boston, 2007.
2. Mool Ch, Gupta and John Ballato, “The Handbook of Photonics”, CRC Press London, 2010.
3. Valery V Tuchin, “Handbook of Photonics for Biomedical Science”, CRC Press, Boca Raton, 2010.
4. Ralf Menzel, “Photonics: Linear and Nonlinear Interactions of Laser Light and Matter”, Springer, New Delhi, 2010.
5. Martina Gerken Nibir K. Dhar, “Proceedings of SPIE: Nanophotonics for Communications, Materials, Devices and Systems”, USA, 2006.

15LN22 BIOMATERIALS AND TISSUE ENGINEERING

3 0 0 3

BIOLOGICAL MATERIALS Biocompatibility- introduction to the biological fluids- material response: swelling and leaching, corrosion and dissolution, deformation and failure, friction and wear - host response: the inflammatory process - coagulation and hemolysis- approaches to thrombo- resistant materials development. (10)

ORTHOPAEDIC & DENTAL IMPLANTS Bone composition and properties - joint replacement - biomaterials used in bone and joint replacement: metals and alloys - ceramics: carbon, alumina, zirconia, bioactive calcium phosphates, bioglass and glass ceramics - polymers - bone cement - composites. Teeth composition and mechanical properties - fillings and restoration materials - materials for oral and maxillofacial surgery - dental cements and dental amalgams - dental adhesives. (10)

CARDIOVASCULAR IMPLANTS vascular implants: vascular graft, cardiac valve prostheses, cardiac pacemakers - blood substitutes - extracorporeal blood circulation devices Biomaterials in ophthalmology - viscoelastic solutions, contact lenses, intraocular lens materials. (8)

TISSUE ORGANIZATION Cell - extracellular matrix - types of tissues - cell as therapeutic agent - cell number and growth rate - tissue dynamics - homeostasis in highly prolific tissue - tissue repair - morphogenesis - cell differentiation - cell migration - cell death. (8)

TISSUE ENGINEERING: Nanomaterials for cell engineering - nano structured extra cellular matrix - electrospin nanofibrous polymeric scaffold - nanolithography in tissue engineering - neural tissue engineering - musculoskeletal - cardiovascular tissue engineering. (9)

Total L: 45

REFERENCES:

1. Temenoff J S and Mikos A G, “Biomaterials: The Intersection of Biology and Materials Science”, Pearson, New Delhi, 2009.
2. Sujata V Bhat, “Biomaterials”, Narosa Publication House, New Delhi, 2009.
3. Fisher J P, Mikos A G and Bronzino J D, “Tissue Engineering”, CRC Press, Boca Raton, 2012.
4. Lanza R, Langer R and Vacanti J, “Principles of Tissue Engineering”, Elsevier Intl, Amsterdam, 2007.
5. Cato T Laurencin and Lakshmi S Nair, “Nanotechnology and Tissue Engineering: The Scaffold”, CRC Press, Boca Raton. 2008.

15LN23 POLYMER ELECTRONICS

3 0 0 3

POLYMERIC MATERIALS: Introduction - Origin, classification, formation of polymers - chain growth and step growth polymerization, copolymerization - Thermoplastics and thermosets - Micro structures in polymers - polymer length, molecular weight, amorphous and crystalline, thermal transitions in plastics. (9)

ELECTRONICALLY CONDUCTING POLYMERS: Band theory, insulators, semiconductors, metals, semimetals, poly (sulfur nitride) and polyacetylene - Synthesis, structure and morphology- Conductivity doping, theory, uses - Phenylene polymers - poly (para-phenylene), poly (phenylene vinylenes), poly (phenylene sulfide) - Polypyrrole and Polythiophene - Polyaniline - Stacked phtalocyanine polymers, polymers with transition metals in the side-group structure. (9)

FABRICATION OF ORGANIC ELECTRONIC DEVICES: Technology, Materials, Printing and Patterning Techniques, Devices, Principle Challenges/Red Brick Walls - Technical Issues in Printed Electrodes for All-Printed Thin-Film Transistor Applications: Surface Roughness of Printed Electrodes - Edge Waviness in Printed Electrodes - Solution-Process Organic TFT - Printed Flexible Organic Light-emitting Diodes: Roll-to-Roll Printing, Gravure Printing of Poly (3, 4-ethylenediocythiophene): poly (styrene sulfonate) and Pentafluorobenzenethiol, Screen Printing of Aluminium Cathode, Characteristics of All-Printed OLEDS, Roll-to-Roll Printed OLED Demonstrators. (9)

SCALING EFFECTS IN ORGANIC TRANSISTORS AND IFS SENSORS: Scaling Behavior in Organic Transistors - Charge Transport in Polycrystalline Organic Semiconductors (Intragrain and Intergrain) - Characterization of Nanoscale Organic Transistors - Channel Length and Temperature Dependence of Charge Transport in Organic Transistors - Field-Dependent Mobility Model for the Scaling Behavior of Charge Transport - Charge Transport in sub-10-nm Organic Transistors - Scaling Behavior of Chemical & Vapour Sensing with Organic Transistors - Transition of Sensing Response by Organic Transistors from Micron-Scale to Nanoscale . (9)

SENSOR APPLICATIONS: Organic Thin-Film Transistors for Inorganic Substance Monitoring - OTFT-Based Sensors, Strain and Pressure Sensors Based on Organic Field-Effect Transistors - Applications for Organic Field-Effect Transistor Sensors - Organic Photo detectors. (9)

Total L: 45

REFERENCES:

1. Harry R Allcock, Frederick W Lampe and James E Mark, “Contemporary Polymer Chemistry”, Pearson, New Delhi, 2003.
2. Frances Gardiner and Eleanor Carter, “Polymer Electronics- A flexible Technology”, iSmithers Rapra Technology Pub. Akron, 2009.
3. Cousins K and Keith Cousins, “Polymers in Electronics”, Smithers Rapra Technology Publishers, Akron, 2006.
4. Ruth Shinar and Joseph Shinar, “Organic Electronics in Sensors and Biotechnology”, Mc Graw Hill, New Jersey, 2009.

15LN24 NANOBIOMATERIALS

3 0 0 3

NATURAL NANOBIOMATERIALS: mineral Constituents of the living systems - major elements, minor and trace elements, toxic elements, biomineralization principles, architecture of bone and teeth, nanohydroxyapatite, nanosilica, silk as nanobiomaterial, microstructure of cocoon silk and spider silk, biomimetic nanomaterials - Biologically inspired electro spun nano fibre and nano tubes, Biomimetic formulation of synergistic nanocomposite materials, biomimetic adhesive design and manufacturing. (10)

DIAGNOSTIC NANOBIOMATERIALS: Intrinsic biocompatibility of nanoparticle in cellular system - Nanobiomaterial as contrast agent, photosensitizer, degradable and non-degradable polymers, degradable and resorbable materials, biocompatible polymer coated magnetic nanoparticles for MRI imaging, gold and silver loaded bioconjugated carbon nanotube and graphene for tumor targeting, Silica / CdSe / CdS / ZnO core - shell nanostructures for optical diagnostics and imaging – multifunctional nanobiomaterials for multi imaging modality approaches. (9)

THERAPEUTIC NANOBIOMATERIALS: Nanobiomaterial as therapeutic agent **-** Targeted, non-targeted delivery; controlled drug release; exploiting novel delivery routes using nanoparticles, Cytotoxicity mechanisms and their potential use in therapy, gene therapy using nanobiomaterials; nanostructures for antibiotics; diseased tissue destruction using nanoparticles, Photodynamic therapy, Magnetically induced hyperthermia. (9)

FUNCTIONAL NANOBIOMATERIALS: Goals of nanomaterial use in healthcare, areas of application- nanovectors, nanobio-generators, nanobiosensors, implantable drug delivery devices, status of tissue engineering of specific organs - bone marrow, skeletal muscle, and cartilage, design and engineering of mesoporous scaffold for hard tissue replacement, choice of materials and process techniques, fabrication of hybrid microswimmers, bionanomaterial applications in environmental remediation. (9)

NANO ENGINEERED SCAFFOLDS: Skin Regeneration by Nanotechnological Approaches, Nanotechnological Advances in Cartilage Repair, Applying Nanotechnology to Bone Reconstruction, Nerve Regeneration, Nanotechnology for Cardiac Tissue Regeneration, Clinical Trials. (8)

Total L: 45

REFERENCES:

1 Yoseph Bar Cohen, “Biomimetics: Biologically Inspired Technologies”, CRC Press, Boca Raton, 2006.
2 Ramakrishna S, Murugan Ramalingam, and Kumar T. S. S., “Biomaterials: A Nano Approach”, CRCPress, London, 2010.
3 Bikramjit Basu and Ashok Kumar K., “Advanced Biomaterials: Processing and Applications”, John Wiley, New Jersey, 2009.
4 Hari Singh Nalwa, “Handbook of Nanostructured Biomaterials and Their Applications In Nanobiotechnology” ,American Scientific Publishers,2005.
5 Cato T. Laurencin, Temenoff J. S. and Mikos A. G., “Biomaterials: The Intersection of Biology and Materials Science”, Pearson, New Delhi, 2009.
6 Astrid Sigel, Helmut Sigel and Roland K. O. Sigel, “Biomineralization: From Nature to Application”, John Wiley, 2010.
7 Stephen Mann, “Biomineralization: Principles and Concepts in Bioinorganic Materials Chemistry”, Oxford Univ. Press, 2001.

15LN25 NANOTOXICOLOGY

3 0 0 3

TOXICOLOGY AT NANO SCALE: Size-specific behavior of nanomaterials - nanotoxicology challenges - carbon nanotubes in practice - postproduction processing of carbon nanotubes - physicochemical properties of nanomaterials as mediators of toxicity - characterization of administered nanomaterials during toxicity studies - C_{60} - Graphene issues. (9)

NANOPARTICLE EXPOSURE: Physicochemical determinants in particle toxicology - nanoparticles vs. micron-size particles - nanoparticle toxicity comparison to larger counterparts - requirement for appropriate model particles - exposure assessment, exposure pathways and their significance - documenting the occurrence and nature of exposures. (9)

INTERACTION WITH BIOMEMBRANES: bio-distribution of nanoparticles - localization of particles in tissues - relevance of drug targeting to nanotoxicology Interaction of nanoparticles with lipid bilayers - cell-level studies of nanoparticle - induced membrane permeability - internalization of cation nanoparticles into cells - placental biological barrier model for evaluation of nanoparticle transfer - transport across placental barrier - assessment of placental transfer. (9)

BIOLOGICAL MECHANISM: nanoparticle disposition - outline of gene-cellular interactions of nanomaterials - overview of dermal effects of nanomaterials - toxicity of nanoparticles in the eye - scientists as moral agents - the business community and corporations as moral agents - policy makers and regulators as moral agents. (9)

ETHICAL ISSUES: ethical and societal implications - the public interface of science technology and human values - origins of the precautionary principle - the citizen as moral agent - the principle of social justice - utilitarian priorities The pressing questions - the players - the funders - the thinkers - the communicators - the arenas combined - the role of fore-sighting - ethics applied to the practical - citizenship in the nano-age - the value of the skeptical optimist. (9)

Total L: 45

REFERENCES:

1. Nancy A, “Monteiro Riviere Lang Tran”, Nanotoxicology, CRC Press, 2014.
2. Deb Bennett Woods, “Nanotechnology: Ethics and Society”, CRC Press, Taylor and Francis Group, 2008.
3. Lynn Goldman and Christine Coussens, “Implications of Nanotechnology for environmental Health Research, National Academic Press, Washington,2007.
4. Patrick Lin, Fritz Allhoff, “Nano-ethics: The Ethical and Social Implications of Nanotechnology”, John Wiley & Sons, New Jersey, 2007.

15LN26 NANOTECHNOLOGY IN TEXTILES

3 0 0 3

INTRODUCTION TO TECHNICAL TEXTILES- Developments in fiber materials-natural fibers- Intervention of Nanotechnology in Textile industry - Nano fiber production: Electrospinning of Nano fibers - Continuous yarns from electrospun nanofibers- Controlling the morphologies of electrospun nanofibers- Producing nanofiber structures by electrospinning for tissue engineering. (9)

CARBON NANOTUBES AND NANO COMPOSITES: Structure and properties of carbon nanotube - polymer nanofibers - Multifunctional polymer nanocomposites for industrial applications -. Multiwall carbon nanotube - nylon-6 nanocomposites from polymerization - Nano-filled polypropylene fibers. (9)

IMPROVING POLYMER FUNCTIONALITY: Nanostructuring polymers with cyclodextrins, Dyeable polypropylene via nanotechnology. Polyolefin/clay nanocomposites. (9)

NANOCOATINGS AND SURFACE MODIFICATION TECHNIQUES: Nanotechnologies for coating and structuring of textiles - Electrostatic self-assembled nanolayer films for cotton fibers - Nanofabrication of thin polymer films - Hybrid polymer nanolayers for surface modification of fibers - Structure-property relationships of polypropylene nanocomposite fibers. (9)

APPLICATIONS: Introduction to Smart Technology for textile and clothing - Areas of applications of smart textile-Pathogen barrier fabric- fibres used for pathogen barrier application. Clothing for extreme climatic conditions - wearable technology for snow clothing, high altitude clothing. Electromagnetic radiation protective clothing. UV resistant, antibacterial, hydrophilic, self-cleaning, flame retardant finishes. (9)

Total L: 45

REFERENCES:

1. Brown P J and Stevens K, “Nanofibers and Nanotechnology in Textiles”, CRC Press, Boca Raton, 2007.
2. Mai Y W, “Polymer Nano Composites”, Woodhead Publishing, New Jersey, 2006.
3. Chang W N, “Nanofibres Fabrication, Performance and Applications”, Nova Science Publishers Inc, New Delhi, 2009.
4. Seeram Ramakrishna, “An Introduction to Electrospinning and Nano Fibers”, World Scientific Publishing Co., Singapore, 2005.

15LN27 NANOTECHNOLOGY FOR ENERGY SYSTEMS

3 0 0 3

RENEWABLE ENERGY: Energy challenges and crisis - development and implementation of renewable energy technologies - current status of solar, wind, tidal and biomass -Energy production, transport, conversion and storage of nanotechnology enabled renewable energy technologies. (10)

SOLAR PHOTOVOLTAICS : Solar radiation, evolution of solar cells, amorphous and crystalline silicon, Thin films, Cadmium telluride solar cell, Copper indium gallium selenide solar cell, Gallium arsenide multi-junction solar cell, Dye-sensitized solar cell, Quantum Dot Solar Cells (QDSCs), Organic/polymer solar cells, hybrid photovoltaic system. (9)

MICRO BATTERIES: Super ionic solids - Nano-ionic materials - thin film battery- electrolyte thin films- capacity of a cell - power and energy density of a cell - polymer electrolytes - super capacitors. Primary lithium batteries - Secondary lithium batteries - Li-ion electrode materials - Applications of Lithium batteries in electronic devices and industries. (8)

FUEL CELL TECHNOLOGY: types of fuel cells and their characteristics, physical and chemical phenomena in fuel cells, - integration and performance for micro-fuel cell systems - design methodologies - micro-fuel cell power sources, fuel cells for stationary and dynamic applications. (9)

HYDROGEN STORAGE METHODS: metal hydrides - hydrogen storage capacity - hydrogen reaction kinetics - carbon-free cycle - gravimetric and volumetric storage capacities - hydriding / dehydriding kinetics - thermal management during the hydriding reaction - size effects - distinctive chemical and physical properties - multiple catalytic effects. (9)

Total L: 45

REFERENCES:

1. Kothari D P, Singal K C and Rakesh Ranjan, “Renewable Energy Sources and Emerging Technologies”, PHI Learning, New Delhi, 2013.
2. Leon Freris and David Infield, “Renewable Energy in Power Systems”, John Wiley & Sons, London, 2009.
3. Chetan Singh Solanki, “Solar Photovoltaics: Fundamentals, Technologies and Applications”, PHI Learning, New Delhi, 2009.
4. Kiehne H A, “Battery Technology Handbook”, Marcel Dekkar, New York, 2003.
5. Viswanathan B and Aulice Scibioh M, “Fuel Cells: Principles and Applications”, Universities Press, Hyderabad, 2009.

15LN28 NANOSTRUCTURES IN MEDICINE

3 0 0 3

NANOMEDICINE: 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. (9)

SMART ASSEMBLIES: Nano and microparticulate delivery systems-the homing device challenge, nanoparticles in biomedical screening and molecular imaging-analyte detection and screening-gold oligonucleotide nanoprobes-fluorescent silica nanoprobes, molecular imaging, targeted radionuclide imaging. (9)

SITE SPECIFIC DRUG DELIVERY: Opsonization of polymer surface-blood compatibility of polymer surfaces-nanospecific blood-nanoparticle interaction-complement activation and cell opsonization-leukocyte activation, suppression of opsonization and nonspecific cell-particle interaction, clinical evaluation of long circulating nanocapsules, virus like nanoparticles for gene therapy. (9)

THERMORESPONSIVE NANOSTRUCTURED MICROCAPSULES: Microcapsules with nanochanneled thermoresponsive layers, microcapsules with sandwiched thermoresponsive membranes, nanogel-matrix membranes, thermocontrolled protein delivery devices. (9)

MICRO AND NANO GELS: Preparation of nanogels-microemulsion polymerization-chemical crosslinking-physiochemical crosslinking, stimuli responsive nanogels, nanogel applications in drug delivery, pH responsive liposomes. (9)

Total L: 45

REFERENCES:

1. Reza Arshady and Kenji Kono, “Smart Nanoparticles in Nanomedicine”, MML series volume 8, Knetus Books, London, 2006.
2. Kewal K Jain, “The Handbook of Nanomedicine”, Humana Press, New Delhi, 2008.
3. Mingjun Zhang and Ning Xi, “Nanomedicine: A Systems Engineering Approach”, Pan Stanford Publishing, Singapore, 2009.
4. Robert A and Freitas Jr, “Nanomedicine Volume IIA: Biocompatibility”, S Karger Ag, Switzerland, 2003.
5. Alf Lamprecht, “Nanotherapeutics Drug Delivery Concepts in Nanosience”, Pan Stanford Publishing, Singapore, 2009.

15LN29 NANOCOMPUTING

3 0 0 3

INTRODUCTION: Nanocomputing and quantum computers - Nanocomputing technologies - Microelectronics to nanoelectronics, nanoelectronics to nanoelectronic computers, nano information processing, prospects and challenges. (5)

TECHNOLOGIES AND IMPERFECTIONS: Digital signals and gates - Silicon nanoelectronics - Nanocomputing in the presence of defects and faults - error detection, masking and reconfiguration - Defect tolerance - approaches for achieving defect tolerance in nanometer domain, tool flow required to achieve defect tolerance,testing,placement and routing - Quadrillion transistor logic systems - cell matrix, overcoming manufacturing defects. (11)

PROBABILISTIC BASED DESIGN FOR NANOSCALE COMPUTATION AND RELIABILITY ISSUES: Introduction - Markov Random Field (MRK) design for structural based faults, design for signal based errors- Tools and techniques for evaluating reliability issues for nano architectures - NANOLAB, NANOPRISM, reliability evaluation of multiplexing based majority systems. (11)

NANOSCALE QUANTUM COMPUTING: Challenges - quantum computation, error correction, computing technologies, fabrication and test challenges, architectural challenges - Quantum dot cellular automata - computing with QCA - QCA clocking and design rules. (9)

OTHER COMPUTING TECHNIQUES AND VERIFICATION OF NANO SYSTEMS: Brief overview of molecular electronics and molecular computing - Use of optics in computing and optical computing paradigms - Role of non linear optics in optical computing - Verification of large scale nanosystems - scalable verification, scalable unbounded and bounded model checking, verification in the presence of unknowns and uncertainties. (9)

Total L:45

REFERENCES:

1. Sandeep K Shukla and Iris Bahar R, “Nano, Quantum and Molecular Computing: Implications to High Level Design and Verification”, Kluwer Academic Publishers, New Delhi, 2004.
2. Vishal Sahni and Debabrata Goswami, “Nanocomputing: The Future of Computing”, Tata McGraw-Hill, New Delh, 2008.
3. Goser K, Glosekotter P and Dienstuhl J, “Nanoelectronics and Nanosystems : From Transistors to Molecular Quantum Devices”, Springer, Heidelberg, 2004.

15LN30 NANOBIOTECHNOLOGY

3 0 0 3

BIOLOGY INSPIRED CONCEPTS: Nanostructuring at surfaces using proteins, self assembled nanobiomaterials, stealth and biomimetic core-corona nanoparticles - nucleic acid in nanobiological devices - nanoparticles for live cell dynamics. (10)

BIOELECTRONICS: biological neurons - function of neuronal cell, biological neuronal cells on silicon modeling. Molecular processor - DNA analyzer as biochip - molecular electronics- DNA as smart glue, DNA as wire template, DNA computers. (7)

NANOBIOMOTORS: General classification of bionanomotors - kinesin motor and nanoactuators, myosin, F_0-F_1 ATPase motor- in vitro generation of F_0-F_1 ATPase motor -bacterial flagella motor-viral DNA packaging motor-helicase-RNA polymerase (9)

NANOPARTICLES IN CANCER THERAPY: Magnetic nano and microparticles for embolotherapy - hyperthermic therapy-delivery of chemotherapeutic drugs-brachytherapy, Thermoresponsive liposomes for hyperthermic chemotherapy assemblies and ultrasound activation. (12)

NANOANALYTICS: Quantum dot biolabeling - nanoparticle molecular labels - analysis of biomolecular structure by AFM and molecular pulling - force spectroscopy - biofunctionalized nanoparticles for Surface Enhanced Raman Scattering and Surface Plasmon Resonance. (7)

Total L: 45

REFERENCES:

1. Niemeyer C M and Mirkin C A, “Nanobiotechnology, Concepts, Applications and Perspectives”, Wiley-Vch, Germany, 2004.
2. David S Goodsell, “Bionanotechnology: Concepts, Lessons from Nature”, Wiley-Liss, New Jersey, 2004.
3. Reza Arshady and Kenji Kono, “Smart Nanoparticles in Nanomedicine”, Kentus Books, London, 2006.
4. Greco R S, Prinz and Smith R. L., “Nanoscale Technology in Biological Systems”, CRC Press, London, 2005.
5. Goser K, Glosekotter P and Dienstuhl J, “Nanoelectronic and Nanosystems - From Transistors to Molecular Quantum Devices”, Springer, New Delhi, 2004.

15LN31 MODELLING OF NANO-CMOS

3 0 0 3

NANO-CMOS SCALING PROBLEMS AND IMPLICATIONS: Design Methodology in the Nano-CMOS Era – Scaling – Overview of Sub-100-nm Scaling Challenges andSubwavelength Optical Lithography – Back-End-of-Line Challenges (Metallization) – Front-End-of-LineChallenges (Transistors) – Process Control and Reliability Lithographic Issues and Mask Data Explosion – NewBreed of Circuit and Physical Design – Modeling Challenges – Need for Design Methodology Changes. (9)

PRACTICALITIES OF SUBWAVELENGTH OPTICAL LITHOGRAPHY: Simple Imaging Theory – Challenges for the 100-nm Node – e-Factor for the 100-nm Node – Corner Rounding Radius – Resolution Enhancement Techniques: Specialized Illumination Patterns – Optical Proximity Corrections –Subresolution Assist Features – Alternating Phase-Shift Masks – Physical Design Style Impact on RET and OPC Complexity – Specialized Illumination Conditions – Two-Dimensional Layouts – Alternating Phase-Shift Masks –masks cost (9)

PROCESS SCALING IMPACT ON DESIGN MIXED-SIGNAL CIRCUIT DESIGN: 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. (9)

ELECTROSTATIC DISCHARGE PROTECTION DESIGN: 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 ProtectionDesign 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/OInterface – 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. (9)

SIGNAL INTEGRITY PROBLEMS IN ON-CHIP INTERCONNECTS: Interconnect Figures of Merit – Interconnect Parasitics Extraction – Circuit Representation of Interconnects – RCExtraction – Inductance Extraction – Signal Integrity Analysis – Interconnect Driver Models – RC InterconnectAnalysis – RLC Interconnect Analysis – Noise-Aware Timing Analysis – Design Solutions for Signal Integrity –Physical Design Techniques – Circuit Techniques (9)

Total L: 45

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).Karl Goser, Peter Glosekotter and Jan Dienstuhl, “Nanoelectronics and Nanosystems”, Springer, New Jersey, 2004.
3. Mick Wilson, Kamali Kannangara, Geoff Smith Michelle Simmons, Burkhard Raguse, Nanotechnology: Basic Science and Emerging technologies, Overseas Press India Pvt.Ltd.,2005.
4. George W. Hanson, “Fundamentals of Nanoelectronics”, Pearson, New Delhi, 2009.

15LN32/15LV28 SYSTEM ON CHIP DESIGN

3 0 0 3

INTRODUCTION TO THE CONCEPT OF SoC: Driving Forces for SoC - Components of SoC - Design flow of SoC - Hardware/Software nature of SoC - Design Trade-offs - SoC Applications - **SYSTEM-LEVEL DESIGN:** Processor selection-Concepts in Processor Architecture: Instruction set architecture (ISA), elements in Instruction Handing-Robust processors: Vector processor, VLIW, Superscalar, CISC, RISC—Processor evolution: Soft and Firm processors, Custom-Designed processors- on-chip memory (10)

SYSTEM-LEVEL INTERCONNECTION: On-chip Buses: basic architecture, topologies, arbitration and protocols, Bus standards: AMBA, CoreConnect, Wishbone, Avalon - Network-on-chip: Architecture-topologies-switching strategies - routing algorithms - flow control, Quality-of-Service- Reconfigurability in communication architectures (8)

IP BASED SYSTEM DESIGN: Introduction to IP Based design, Types of IP, IP across design hierarchy, IP life cycle, Creating and using IP - Technical concerns on IP reuse - IP integration - IP evaluation on FPGA prototypes (10)

SOC IMPLEMENTATION: Study of processor IP, Memory IP, wrapper Design - Real-time operating system (RTOS), Peripheral interface and components, High-density FPGAs - EDA tools used for SOC design. (9)

SOC TESTING: Manufacturing test of SoC: Core layer, system layer, application layer-P1500 Wrapper Standardization-SoC Test Automation (STAT) (8)

Total L : 45

REFERENCES:

1. Michael J.Flynn, Wayne Luk, "Computer system Design: System-on-Chip", Wiley-India, 2012.
2. Sudeep Pasricha, Nikil Dutt, "On Chip Communication Architectures: System on Chip Interconnect", Morghan Kaufmann Publishers, 2008.
3. W.H.Wolf, "Computers as Components: Principles of Embedded Computing System Design", Elsevier, 2008.
4. Patrick Schaumont "A Practical Introduction to Hardware/Software Co-design", Patrick Schaumont, 2nd Edition, Springer, 2012.
5. Lin, Y-L.S. (ed.), "*Essential issues in SOC design: designing complex systems-on-chip.* Springer, 2006.
6. Wayne Wolf, "Modern VLSI Design: IP Based Design", Prentice-Hall India, Fourth edition, 2009.
7. http://www.altera.com
8. http://www.xilinx.com

15LN33 PRODUCT DESIGN, MANAGEMENT TECHNIQUES AND ENTREPRENEURSHIP

3 0 0 3

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. (9)

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. (9)

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. (9)

ENTREPRENEURIAL COMPETENCE & ENVIRONMENT: Concept of entrepreneurship - entrepreneurship as a career - personality characteristic a successful entrepreneur - knowledge and skill required for an Entrepreneur - Business environment - entrepreneurship development training - centre and state government policies and regulations - international business. (9)

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. (9)

Total L: 45

REFERENCES:

1. Karal T Ulrich and Steven D Eppinger, "Product Design and Development", McGraw- Hill, New Delhi, 2008.
2. Koontz H and Cyril O Donnellm, "Essentials of Management", McGraw Hill, New Delhi, 2008.
3. Joseph L Massie, "Essentials of Management", Prentice Hall, New Delhi.
4. Robert D Hisrich and Michael P Peters, "Entrepreneurship", McGraw Hill, New Delhi, 2011.

15LN34/15LW44/15LC50 DATA STRUCTURES AND ALGORITHMS

2 2 0 3

INTRODUCTION: Software Development process – Data structures - Abstract Data Types - Analysis of algorithms - Best, worst and average case time complexities - notations. (4+4)

ARRAYS: Operations - Implementation of one, two, three and multi dimensioned arrays – Sparse and dense matrices - Applications. (4+6)

STACK AND QUEUE: Stack operations - implementations - Applications: Function handling - Recursion – Expression Evaluation. Queue - operations - implementations - Priority Queues - Dequeues - Applications: Job scheduling. (6+4)

LISTS : Operations - Singly linked lists, doubly linked lists, Circular lists - Applications – Linked Stacks - Linked queues. (6+4)

TREES AND GRAPHS: Tree Terminologies - Implementation - Binary Tree: Properties –representation of trees, operations-Traversals- Expression trees - Infix, Postfix and Prefix expressions – Dijkstra's Algorithms-Floyd's Algorithm. Graph Terminologies-representations-graph search methods: Breadth first search, Depth first search, Minimum spanning trees-Multistage graph. (6+6)

SORTING: Insertion sort - Selection sort - Bubble sort - Radix sort - Algorithms and their time complexities. (4+6)

TUTORIAL COMPONENT:

1. Analysis of algorithms
2. Implementation of stack and queue
3. Evaluation of expressions
4. Singly and doubly linked lists implementation
5. Binary tree traversal.
6. Single source shortest path algorithm – Dijkstra's algorithm
7. All pairs shortest path problem- Floyd's Algorithm
8. Graph search method implementation

Total L: 30+ T: 30 = 60

REFERENCES:

1. Sahni Sartaj, "Data Structures, Algorithms and Applications in C++", Universities Press, Hyderabad, 2005.
2. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", Pearson Education, New Delhi, 2007.
3. Robert L Kruse, Bruce P Leung and Clovin L Tondo, "Data Structures and Program Design in C", Pearson Education, New Delhi, 2009.
4. Vijayalakshmi Pai G A, "Data Structures and Algorithms: Concepts Techniques and Applications", McGraw-Hill, 2009.
5. Chitra A, Rajan P T "Data Structures", Tata Mc Graw Hill Education, 2008.
6. Ellis Horowitz , Sartaj Sahni and Sanguthevar Rajasekaran, "Computer Algorithms/C++", Orient Black Swan, 2008.

15LN35 HIGH VACUUM TECHNOLOGY

3 0 0 3

ELEMENTS OF HIGH VACUUM SYSTEM: Study of a system to produce high vacuum, pumping speed, conductance of an orifice and tube, losses in pumping speed and determination of pumping speed. (7)

TYPES OF PUMPS: Rotary pump, diffusion pump, ejector pump, turbo molecular pump, roots blower pump, getter ion pump, sputter ion pump, cryosorption pump, cryo-condensation pump - working principle, construction, operation - pressure range, limitations and pumping characteristics. (9)

LEAK DETECTION AND PREVENTION: Outgassing of materials - real and virtual leaks - methods of leak detection - sealing substance outside and pressure change inside - rate of pressure rise method - halogen leak detector and the helium leak detector). Leak prevention - Vacuum seals: Common seals using elastomers, sliding and rotating seals, electrical lead throughs, (9)

VACUUM COMPONENTS: Baffles and traps: Some designs of baffles, inline trap, right angle trap, dished trap, re-entrant trap, spherical trap and sorption trap, pumping losses in baffles and traps (qualitative). Vacuum valves**:** Gate valve, disc valve, flap valve, globe valve, needle valve and diaphragm valve. Backable valves (Apart, Theorres and Nier tange valve). Best practices involved in soldering, welding and brasing of components. Flange connections with Elastomer gaskets and metal gaskets. (11)

VACUUM MEASUREMENTS: Primary gauges: Viscosity gauge, radiometer types gauge, Mcleod gauge with construction and working principle. Secondary gauges**:** Pirani gauge, thermocouple gauge, thermionic ionization gauge, cold cathode ionisation gauge (Penning gauge) - working principle, construction and operation limits. Bayard Alpert gauge. (9)

Total L: 45

REFERENCES:

1. Rao V V, Ghosh T K and Chopra K L, "Vacuum Science and Technology', Allied publishers Ltd,2008.
2. Leon I Maissel and Reinard Glang, "Hand Book of Thin Film Technology", McGraw Hill, 1990.
3. Green G L, "Design and Construction of Small Vacuum System", Chapman and Hall Ltd, 1998.
4. Alfert E Barrington, "High Vacuum Engineering", Prentice Hall, 1994.
5. Andrew Guthrie, "Vacuum Technology", John Wiley, 1993.

ONE CREDIT COURSES

For the detailed Syllabi of all the one credit courses offered by Electronics and Communication Engineering department which are listed in this programme scheme refer to the syllabi of M.E Communication Systems programme.

For the detailed syllabi of the electives and one credit courses offered by other departments refer to the syllabi of M.E- Automotive Engineering offered by Automobile Engineering Department.