CENTRE FOR NANOSCIENCE AND TECHNOLOGY

Madanjeet School of Green Energy Technologies

PONDICHERRY UNIVERSITY

(Accredited with 'A' Grade by NAAC)

PUDUCHERRY - 605 014

Ph.D - Nanoscience and Technology Programme

Syllabus & Regulations

2016-17 ONWARDS

Ph.D. - Nanoscience and Technology Programme

Syllabus (2016-17 Onwards)

Code No.	Subject	Course Type	Class hours	University Examination			Credit
				Internal	External	Total	
NAST-821	Research Methodology for Nanoscience and Technology	HC	3	40	60	100	PASS
SPECIFIC AREA OF RESEARCH PAPER (Any one to be suggested by the Doctorial Committee)							
NAST-822	Nanostructured Materials for Clean Energy Systems	SC	3	40	60	100	PASS
NAST-823	Polymers and Nanocomposites	SC	3	40	60	100	PASS
NAST-824	Industrial Nanotechnology	SC	3	40	60	100	PASS
NAST-825	Nanomagnetic materials and devices	SC	3	40	60	100	PASS
NAST-826	Surface Engineering in Nanotechnology	SC	3	40	60	100	PASS
NAST-827	Nano-photonics and Biophotonics	SC	3	40	60	100	PASS
NAST-828	Advanced Nanobiotechnology	SC	3	40	60	100	PASS
XXX-829	Any other courses offered by the Centre / Other Departments at M.Tech level.	SC	3	40	60	100	PASS
NAST-820	**Research Seminar**	HC	1	-	-	-	PASS
					Total	**400**	PASS

* **HC – Hard Core Course; SC – Soft Core Course;**

Candidates with M.Tech/ M.Phil are exempted from taking the Part - I examination.

Other candidates should take the Part-I examination, at the end of the first year. NAST-821 is compulsory for them, and also any one specific area of research paper (NST-822 to NAST- 829) to be suggested by the Doctoral Committee at M.Tech level.

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The Part-I examination will be conducted by the Supervisor/HoD (as per the University policy).

NAST- 820 & 821 are compulsory for all Ph.D scholars.

Eligibility for Admission:

- A candidate having M.Tech in Nanoscience and Technology / Nanotechnology / Nano-Electronics / Nano-Biotechnology with the background of Electrical/ Electronics/Instrumentation / Chemical / Mechanical / Metallurgical Engineering / Polymer Science and Engg.,/ Materials Science and Engg.,/ Energy Technology/, Biotechnology and other relevant subjects with a minimum of 55% of marks. (OR)

- Masters degree in Physics /Applied Physics / Chemistry/ Applied Chemistry/ Materials Science / Environmental Sciences / Biotechnology / Bio-Chemistry with a minimum of 55% of marks.

Syllabus for Courses

NAST- 821: Research Methodology for Nanoscience and Technology

UNIT- I **(9 hrs)**

Synthesis of Nanomaterials

Chemical processes: Chemical precipitation and co-precipitation, polyol, and borohydrate reduction methods, Sol-Gel synthesis; Microemulsions synthesis, Hydrothermal, Solvothermal synthesis methods, Microwave assisted synthesis; Sonochemical assisted synthesis, Core-Shell nanostructure, Organic-Inorganic hybrid nanocomposites, Quantum dot (QDs) synthesis.

UNIT- II **(9 hrs)**

Physical processes:

Fabrication of Nanomaterials by Physical Methods: Inert gas condensation, Arc discharge, RF- plasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy (MBE), Chemical vapour deposition (CVD) method. Template assisted synthesis, Catalyst assisted chemical vapour deposition (CCVD).

UNIT- III **(9 hrs)**

Nanostructured Materials Characterization Techniques

X-ray diffraction (XRD), SEM, EDAX, TEM, Elemental mapping, FTIR, UV-Visible spectrophotometer, Laser Raman Spectroscopy, Nanomechanical Characterization using Nanoindentation, Differential Scanning Calorimeter (DSC), Differential Thermal Analyzer (DTA), Thermo gravimetric Analysis (TGA), TEM, X-ray Photoelectron Spectroscopy (XPS), Electrochemcial Characterization measurements.

UNIT-IV **(9 hrs)**

Physical Properties of Nanostructured Materials

Size effect of Nanomaterials: Size, shape, density, melting point, wet ability and specific surface area. Diffusion properties: Diffusion laws and mechanism - Applications of diffusion. Mechanical behavior: Stress – strain behaviour, tensile strength, microhardness, wear resistance, and corrosion resistance behaviour. Thermal properties: Thermal conductivity, thermal expansion and thermal expansion coefficient. Electrical properties: Electrical conductivity, band gap tuning - band gap determination, Hall effect and its applications. Dielectric properties: Dielectric constant and its significance – Piezo electric and ferro electric materials and their behaviour and applications. Magnetic properties: Magnetic hysteresis – Superparamagnetism - Optical properties: Photoconductivity, Electroluminescence, Photoluminescence, Jablonski diagram, fluorescence and phosphorescence, Optical properties of nanostructures.

UNIT- V **(9 hrs)**

Nanotechnology - Environmental and health effects

Environmental pollutants in air, water, soil, hazardous and toxic wastes, application of nanotechnology in remediation of pollution. - The challenge to occupational health and hygiene, toxicity of nanoparticles, effects of inhaled nanosized particles, skin exposure to nanoparticles, impact of CNT s on respiratory systems, hazards and risks of exposure to nanoparticles, monitoring nanoparticles in work place and sensors.

Intellectual property, business development: Definition of intellectual property, patents and publications, national and international patents, copy right laws, trade secrets, confidentiality agreements with the companies, legal aspects. - Development of business in nanoscience and technology, joint ventures with local and foreign companies, science innovation parks, product development, proof of concept, scaling up of a product.

TEXT BOOKS

1. Research Methodology- Methods and Techniques, C.K.Kothari, New Age International, 2nd Edn., New Delhi (2004)
2. Research Methods, Donald H.McBurney, Thomson Asia PVT Ltd., Singapore (2002).
3. Computational methods in Physics and Engineering, 2nd Edition, Samuel S.M. Wong, World Scientific-Singapore (2003)
4. Introduction to Computer simulation methods, Gould, Tobochnik, Addition Weekly, 2006.
3. Introduction to Numerical analysis second edition F. B. Hildebrand, Dover Publications, Inc. New York (1987)
4. Numerical Recipes in Fortran / F-90 / C, W.H. Press et. al., Cambridge Univ. Press (1996)
5. Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge UK 2005.
6. Chemistry of Nanomaterials: Synthesis, properties and applications, CNR Rao et. al.
7. Fundamental Properties of Nanostructured Materials, Ed. D. Fiorani (World Scientific, Singapore,(1994).
8. Nanostructured Materials and Nanotechnology – II, Eds. Sanjay Mathur and Mrityunjay Singh, Willey, 2008.
9. Nanostructured Materials, Edited by Carl C. Koch, Noyes Publications, New York, 2002.
10. M.S.Vijaya,G.Rangarajan, Materials Science , Tata McGraw-Hill publishing company Ltd., New Dehli

REFERENCE BOOKS

1. Ferziger, J. H., Numerical Methods for Engineering Applications, 2nd ed., Wiley-Interscience (1998).
2. Computational Physics, J. M. Thijssen, Cambridge University Press, Cambridge, (1999).
3. Active Metals: Preparation, characterization, applications – A. Furstner, Ed., VCH, New York ,1996.
4. Characterization of Nanophase materials – Z.L Wang (ed), Wiley-VCH, New York , 2000.
5. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim , 2004.
6. Nanostructured Silicon – based powders and composites – Andre P Legrand, Christiane Senemaud, Taylor and Francis, London , 2003.
7. Nanocrystalline Materials, A.I. Gusev and A. A. Rempel, Viva Books, New Delhi, 2008.

8. The Physics and Chemistry of Solids, S.R.Elliott, John Wiley & Sons, England, 1998.
9. Properties of Materials, Robert E.Newnham,Oxford University Press, 2005.

SPECIFIC AREA OF RESEARCH PAPER
(Any one to be suggested by the Doctorial Committee)

NAST-822: Nanostructured Materials for Clean Energy Systems

UNIT-I **(9 hrs)**

Fundamental Concepts in Energy Systems

Electrochemical Cell, Faraday's laws, Electrode Potentials, Thermodynamics of electrochemical cells, Polarization losses in electrochemical cells, Electrode process and kinetics, Electrical double layer, Photoelectrochemical cell, thermoelectric effect.

UNIT-II **(9 hrs)**

Nanomaterials for Energy Conversion Systems

Issues and Challenges of functional Nanostructured Materials for electrochemical Energy, Conversion Systems, Fuel Cells, Principles and nanomaterials design for; Proton exchange membrane fuel cells (PEMFC); Direct methanol fuel cells (DMFC); Solid-oxide fuel cells (SOFC), Current status and future trends.

UNIT-III **(9 hrs)**

Nanomaterials for Photovoltaic Solar Energy Conversion Systems

Principles of photovoltaic energy conversion (PV), Types of photovoltics Cells, Physics of photovoltaic cells, Organic photovoltaic cell cells, thin film Dye Sensitized Solar Cells, Quntum dot (QD) Sensitized Solar Cells (QD-SSC), Organic-Inorganic Hybrid Bulk Hetero Junction (BHJ-SC) Solar cells, Current status and future trends.

UNIT-IV **(9 hrs)**

Nanomaterials for Energy Storage (Batteries) Systems

Issues and Challenges of functional Nanostructured Materials for electrochemical Energy Storage Systems, Primary and Secondary Batteries (Lithium ion Batteries), Cathode and anode materials, Nanostructured Carbon based materials, Nano-Oxides, Novel hybrid electrode materials, Current status and future trends.

UNIT-V **(9 hrs)**

Nanomaterials for Energy Storage (Capacitor) Systems

Capacitor, Electrochemical supercapacitors, electrical double layer model, Principles and materials design, Nanostructured Carbon based materials, Redox capacitor Nano-Oxides, Conducting polymers based materials, Current status and future trends.

TEXTBOOK

1. Electrochemical methods: Fundamentals and Applications, Allen J.Bard and Larry R. Faulkner, 2nd Edition John Wiley & Sons. Inc (2004)
2. D. Linden Ed., Handbook of Batteries, 2nd edition, McGraw-Hill, New York (1995)

3. G.A. Nazri and G. Pistoia, Lithium Batteries: Science and Technology, Kulwer Acdemic Publishers, Dordrecht, Netherlands (2004).
4. J. Larmine and A. Dicks, Fuel Cell System Explained, John Wiley, New York (2000).

REFERENCE BOOK

1. Science and Technology of Lithium Batteries-Materials Aspects: An Overview, A. Manthiram, Kulwer Academic Publisher (2000).
2. M. S. Whittingham, A. J. Jacobson, Intercalation Chemistry, Academic Press, New York (1982).
3. M. Wakihara, O. Yamamoto, (Eds.) Lithium Ion Batteries: Fundamentals and Performance, Wiley –VCH , Weinheim (1998).

NAST-823: Polymers and Nanocomposites

UNIT-I **(9 hrs)**

Basic Aspects: Classification - Some basic definitions - Addition and condensation polymerizations, and copolymerization - Mechanism of free radical, cationic and anionic polymerizations – Nomenclature - Tacticity – Glassy solids: Glass transition and melting temperatures and their determination by DSC - Factors affecting Tg, importance of Tg, relationship between Tm and Tg and their control - Crystallinity in polymers: Degree of crystallinity, factors affecting crystallinity of polymers, effect of crystallinity on the properties of polymers.

Polymerization Techniques: Bulk, Solution, Suspension and Emulsion polymerizations - Polymerization using metal catalysts and surfactants.

UNIT-II **(9 hrs)**

Molecular weight of polymers: Number average, weight average and viscosity average molecular weights of polymers - Determination of molecular weight of polymers by GPC and viscometry methods. **Speciality polymers:** Bio-polymers, Bio-degradable polymers, Fire retardant / Thermally stable polymers, Polymer electrolytes, Liquid armor polymers and Liquid crystalline polymers.

UNIT-III **(9 hrs)**

Conducting Polymers

Discovery – Structural characteristics and doping concept - Charge carriers and conducting mechanism – Classification of conducting polymers: Intrinsic and extrinsic conducting polymers - Chemical and electrochemical methods of the synthesis of conducting polymers – Applications of conducting polymers in corrosion protection, sensors, electronic and electrochemical energy devices.

UNIT-IV **(9 hrs)**

Polymer Nanocomposites

Definition of nanocomposites - Nanofillers, Classification of nanofillers, Synthesis and properties of nanofillers - Types of nanocomposites – Synthesis of nanocomposites: Direct mixing, solution mixing, In-situ polymerization - Polymer/ Metal oxide nanocomposites, diblock copolymer based nanocomposites, Polymer/CNTs and Polymer/Nanoclay based composites and their properties and functional applications.

UNIT-V **(9 hrs)**

Other Kinds of Nanocomposites: Fractal based Glass – metal nanocomposites - Core-shell structured nanocomposites - Super hard nanocomposites - Self-cleaning nanocomposites - Metal matrix nanocomposites: Metal with nanoceramic fillers such as SiC, CeO_2, TiO_2, ZrO_2 PTFE, CNTs and their mechanical, corrosion resistance properties and functional applications.

TEXT BOOKS

1. Alfred Ruiden, Elements of Polymer Science and Engineering, Elsevier Science, 1998.
2. Bill Meyer, A Text Book of Polymer Chemistry, John Wiley & Sons, Singapore, 1994.
3. Gowariker and Viswanathan, Polymer Science, Wiley Eastern, 1986.
4. Nanostructured Conductive Polymers, Editor. Ali Eftekhari, Wiley, 2010.
5. Nanocomposites - Science and Technology - P. M. Ajayan, L.S. Schadler, P. V. Braun, Wiley-VCH, 2004.

REFERENCE BOOKS

1. George Odian, Principles of Polymerization, John Wiley & Sons, 1933
2. Conducting polymers with micro or nano meter structure, Meixiang Wan, Springer, 2008.
3. Polymer-Clay Nanocomposites, T.J. Pinnayain, G.W.Beall, Wiley, New York, 2001.
4. Composite Materials, Deborah D.L.Chung, Springer, 2002.

NAST -824: Industrial Nanotechnology

UNIT-I **(9 hrs)**

Nanotechnology in Electrical and Electronics Industry

Advantages of nano electrical and electronic devices – Electronic circuit chips – Nanosensors and actuators, Optical switches – Diodes and Nano-wire transistors - Memory storage – Lighting and displays – Filters (IR blocking) – Quantum computers – Energy devices – Medical diagnosis – Conductive additives - Lead-free solder – Nanocoatings –EMI shielding.

UNIT-II **(9 hrs)**

Nanotechnology in Textiles and Cosmetics

Textiles: Nanofibre production - Electrospinning – Controlling morphologies of nanofibers – Nano-fillers embedded polypropylene fibers – Bionics – Swim-suits with shark-skin effect, Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, anti-bacterial, hydrophilic, self-cleaning, flame retardant finishes) – Modern textiles (Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof clothes), Nanopolymers in medical textiles.

Cosmetics: Formulation of Gels, Shampoos, Hair-conditioners (Micellar self-assembly and its manipulation) – Sun-screen dispersions for UV protection using titanium oxide – Colour cosmetics.

UNIT- III **(9 hrs)**

Nanotechnology in Defence

Military applications of Nanotechnology - Artificial intelligence materials - Propulsion – Vehicles - Propellants and Explosives – Camouflage distributed sensors - Amour protection - Conventional weapons - Soldier systems - Implanted systems, Body manipulation - Autonomous systems - Mini-/Micro robots - Bio-technical hybrids - Small satellites and Space launchers - Nuclear weapons - Chemical weapons - Biological weapons - Chemical/Biological protection.

UNIT- IV **(9 hrs)**

Nanotechnology in Agriculture and Food Technology

Nanotechnology in Agriculture - Precision farming, Smart delivery system – Nanofertilizers: Nanourea and mixed fertilizers, Nanofertigation - Nanopesticides, Nano-seed Science.

Nanotechnology in Food industry – Nanopackaging for enhanced shelf life - Smart/Intelligent packaging - Food processing and food safety and bio-security – Electrochemical sensors for food analysis and contaminant detection.

UNIT-V **(9 hrs)**

Nanotechnology in Environmental and Health Effects

Environmental pollutants in air, water, soil, hazardous and toxic wastes - Application of Nanotechnology in remediation of pollution in Industrial and waste water treatment – Drinking water and Air/Gas purifications - The challenge to occupational health and hygiene, toxicity of nanoparticles, effects of inhaled nanosized particles, skin exposure to nanoparticles, impact of CNTs on respiratory systems, hazards and risks of exposure to nanoparticles, monitoring nanoparticles in work place and sensors.

TEXTBOOK

1. P. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead publication, London, 2006.
2. J. Altmann, Routledge, Military Nanotechnology: Potential Applications and Preventive Arms Control, Taylor and Francis Group, 2006.
3. Jennifer Kuzma and Peter VerHage, Nanotechnology in agriculture and food production, Woodrow Wilson International Center, (2006).
4. Lynn J. Frewer, Willehm Norde, R. H. Fischer and W. H. Kampers, Nanotechnology in the Agri-food sector, Wiley-VCH Verlag, (2011).
5. P. J. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead Publishing Limited, Cambridge, (2007).
6. Q. Chaudry, L.Castle and R. Watkins Nanotechnologies in Food, RSC Publications, 2010.
7. W.N.Chang, Nanofibers Fabrication, Performance and Applications, Nova Science Publishers Inc., (2009).

REFERENCE BOOK

1. Y-W. Mai,Polymer Nano composites, Woodhead publishing, (2006).
2. Udo H. Brinker, Jean-Luc Mieusset (Eds.), Molecular Encapsulation: Organic Reactions in Constrained Systems,Wiley Publishers (2010).
3. Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V. Braun.

NAST-825: Nanomagnetic Materials and Devices

UNIT-I **(9 hrs)**

Magnetism of the solid state

Basics of magnetic materials, magnetic flux, magnetization, magnetic induction, susceptibility and permeability, diamagnetism and diamagnetic susceptibility, Paramagnetism, Curie law and Curie-Weiss law, Pauli paramagnetism, Ferromagnetism, hysteresis, magnons, domain theory, ferrimagnetism, antiferromagnetism

UNIT-II **(9 hrs)**

Giant magnetoresistance

Introduction to spintronics, magnetoresistance in normal metals, MR ratios, Giant magnetoresistance in ferromagnetic multi layers and superlattices, co-operative phenomena and magnetization reversal, applications in spin valve and read heads, comparison of GMR and AMR, oscillation of coupling energy, non-coupling type GMR, CPP and CIP GMR, GMR in nanograins, mechanism of GMR.

UNIT-III **(9 hrs)**

Tunnel magnetoresistance

Introduction to tunnel magneto resistance, ferromagnetic tunnel junctions, experiments for TMR, phenomenological theory of TMR, MR ratio and spin polarization, factors influencing TMR, MR ratio for Fe/MgO/ Fe system, oscillations in TMR, tunnel junctions with manganites, Heusler alloys, nanoscale graunules, Coulomb blockade in tunnel junctions.

UNIT-IV **(9 hrs)**

Ballistic magnetoresistance and Magnetic nanostructures

Ballistic magneto resistance, conductance quantization in quantum confined semiconductors, metals. Anisotropic maneto resistance and applications, magnetism of nanoparticles, nanoclusters, nanowires, hard and soft magnetic materials and their applications, media for extremely high density recording, magnetic sensors, ferro fluids, spinglass- magnetic properties and electronic structure

UNIT-V **(9 hrs)**

Nanobiomagnetism

Magnetic targeting, magnetic separation and detection, magnetic tweezers, drug and gene delivery, chemo therapy, MRI, magnetic contrast agents, hyperthermia, application of various nanomagnetic materials in biotechnology, superparamagnetism, core-shell structures and their applications, iron oxide and novel Nanomaterials.

TEXT BOOKS

1. Advanced magnetic nanostructures, Ed. D. Sellmyer, R. Skomski, Springer, 2009
2. Magnetic nanostructures, Ed. M.A. Reed, American Scientific Publishers, 2002
3. Nanostructured magnetic materials and their applications, Ed. D. Shi, B. Aktas, L. Pust, F. Mikailov, Springer , 2002
4. Introduction to Magnetic Materials, B. D. Cullity, Wiley, 1972.

REFERENCE BOOKS

1. Magnetism in the solid state, P. Mohn, Springer series in the solid state, sciences,
2. Handbook of Thin Film Materials, volume 5, edited by H.S Nalwa, American Scientific Publishers, 2002
3. Encyclopedia of nanoscience and nanotechnology, Edited by H.S. Nalwa, American Scientific Publishers, 2007
4. Magnetism – fundamentals, Edited by E. du Tremolet de Lacheisserie, D. Gognoux, M. Schlenker, Springer, 2003
5. Advances in nanoscale magnetism, Ed. B. aktas, F. Mikailov, Springer,2009
6. Spintronics: fundamentals and applications, I. Zutic, J. Fabian and S. Das Sarma, Rev. Mod. Phys, 76, 323 (2004)
7. Spin electronics, M. Ziese and M.J. Thornton, Springer, 2001

NAST-826: Surface Engineering for Nanotechnology

UNIT-I **(9 hrs)**

Introduction to Surfaces

Surfaces and Interfaces – Importance of Surfaces in Nano Regime – Thermodynamics of surfaces – surface energy – notation of surface structures – surface reconstruction – Surface and interfacial tension and measurement– contact angle and wetting – surfactants, and interfacial forces – Review of Surface Characterization Techniques – optical, topographic, chemical and mechanical properties (XPS, PIXE, RBS, SIMS, LEED, RHEED)

UNIT-II **(9 hrs)**

Processes at Solid Surfaces

Adsorption – Physisorption and Chemisorption – Adsorption isotherms (Langmuir and BET) – Reaction Mechanism (Langmuir-Hinshelwood and Eley-Rideal) – Sticking Probability –Types of Catalyst – Homo vs Hetero - Properties and preparation of Catalyst – TON, TOF, E factor - Surface and electronic properties of metal and metal oxide catalyst and its principle behind catalysis – Sabatier Principle – Bronstedt – Polanyi relation - Role of Surfaces, Interfaces, Morphology in Catalysis– Active sites incatalysis & determination – porous materials and supported catalyst – spillover and reverse spillover - Sensor

UNIT-III **(9 hrs)**

Role of Surfaces in Bio-nano interactions

Adhesion and its importance – Adhesion vs cohesion – Work in adhesion and cohesion - Theories on adhesion (Bradley, Hertz, JKR) - Methods of adhesion measurement (Scotch Tape, Peel test, Scratch, Blister, Ultrasonic and acoustic microcavitation methods) – Adhesion measurement in cell (observational, probing and counting techniques) - Surface modification and adhesion - Adhesion of nanoparticles, cells and between nanoparticle & cells - Cancer cell surface interaction.

UNIT-IV **(9 hrs)**

Tribological Aspects of Surfaces

Tribological aspects of adhesion, friction and wear – Friction and Friction Types – Theories of Macro (Amontons, Coulomb) and Nanoscale friction (Tomlinson, Frenkel-Kontorova, Bowden and Tabor models)– Difference between macro and micro/nano tribology- Wear – Wear Mechanisms and types – identification of different mechanisms – Wear theory (Archard, Rabinowictz, Bassani and D'Acunto Theory)– Characterization techniques for friction and wear – Tribometer, Friction Force Microscopy, Nanoindentation and Nanoscratching – Methods to reduce wear and Friction –Fracture –Lubrication –Surface Coatings

UNIT-V **(9 hrs)**

Surfaces in Multidisciplinary Applications

Colloids– Optical and Electrical properties – Colloids in Drug Delivery – Electrical and Electronic properties of Surfaces –zeta potential - Corrosion – Coatings for corrosion protection –High temperature issues - New coating concepts in multilayer structures – thermal barrier coatings. Bioinspired materials – Tribology in Human Body, Artificial organs and Medical devices –Nanosurfaces in Energy, Environmental, Automobile and Industrial Applications

TEXT BOOKS

1. Gabor A. Somorjai, Yimin Li, Introduction to Surface Chemistry and Catalysis, John Wiley & Sons, New Jersey, 2010.
2. HaraldIbach, Physics of Surfaces and Interfaces, Springer-Verlag, Berlin, 2006.
3. Pankaj Vadgama, Surfaces and interfaces for biomaterials, First Edition, CRC Press, Boca Raton, 2005.
4. Peter J. Blau, Friction Scienceand Technology- From concepts to applications, Second Edition, CRC Press, Boca Raton, 2009
5. B. Bhusan, Modern Tribology Handbook, CRC Press, Boca Raton, 2005.
6. N. Birks, G. H. Meier, F. S. Pettit, Introduction to the high temperature oxidation of metals, Second edition, Cambridge University Press, 2006.

REFERENCE BOOKS

1. I. Chorkendorff, J.W. Niemantsverdriet, Concepts of Modern Catalysis and Kinetics, First Edition, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2003.
2. Didier Astruc, Nanopaticles and catalysis, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2008.
3. Ryan Richards, Surface and Nanomoecular Catalysis, Taylor & Francis, Boca Raton, 2006.
4. Jeremy Ramsden, Biomedical Surfaces, Aptech House, Inc., Boston, 2008.
5. Renate Forch, HolgerSchonherr, and A. Tobias A. Jenkins, Surface Design: Applications in Bioscience and Nanotechnology, Wiley -VCH Verlag GmbH & Co. KGaA, Weinheim, 2009

NAST-827: Nanophotonics and Biophotonics

UNIT-I **(10 hrs)**

Introduction to photonics

Electromagnetic properties of nanostructures – Wavelength and Dispersion laws – Density of states – Maxewells and Helmholtz equations - Photonic band-structure and photonic band gap - Propagation of light in periodic media. Band structure in periodic media – 1D and 2D cases.

UNIT-II **(10 hrs)**

Photonic Crystals

Fabrication of photonic crystals : Photonic crystals by self-assembly - Photonic Crystals by Microfabrication - Photonic Crystals with Tunable Properties.

Harmonic generation in photonic nanostructures: Metal nanoparticles, Nanoparticles in monolayer – planar photonics structures - photonic crystals.

UNIT-III **(9 hrs)**

Photobiology

Interaction of light with cells: Light absorption in cells – Light induced cellular processes – photochemistry induced by exogenous photosensitizers – Interaction of light with tissues: Nature of Optical interactions – Measurement of optical properties of a tissue – Light-induced Processes in Tissues – Autofluorescence, photochemical processes, thermal effects, photoablation, plasma induced ablation and photodisruption.

UNIT-IV **(8 hrs)**

Nanotechnology for biophotonics

The interface of bioscience, nanotechnology and photonics - Semiconductor quantum dots for bioimaging – Metallic nanoparticles and nanorods for Biosensing – Up-converting nanophores - Inorganic nanoparticles – Pebble nanosensors for Invitro Bioanalysis - Nanoclinics for optical diagnostics and Targeted therapy.

UNIT-V **(8 hrs)**

Biomaterials for Photonics

Photonics and Biomaterials – Bioderived materials (Baceriorhodopsin, Green Fluorescent Protein, DNA, Bio-objects and biocolloids) – Bioinspired materials – Biotemplates (DNA and Viruses as templates) – Bacteria as synthesizers for photonic polymers.

TEXT BOOKS

1. Introduction to Nanophotonics, Sergey V. Gaponenko, Cambridge University Press, New York, (2010)
2. Photonic crystals: Physics and Technology, (Eds.) C. Sibilia, T. M. Benson, M. Marciniak, T.Szoplik, (2008)
3. Photonic Crystals (2nd edition), John D. Joannopoulos, Steven G. Johnson, Joshua N. Winn, Robert D. Meade, Princeton University Press, (2008)
4. Introduction to Biophotonics, Paras N. Prasad, John Wiley and Sons, New Jersey, (2003)

REFERENCE BOOKS

1. Photonic Crystals: Towards Nanoscale Photonic Devices, J.-M. Lourtioz • H. Benisty V. Berger, J.-M. Gerard • D. Maystre • A. Tchelnokov, Springer-Verlag Berlin Heidelberg, (2005)
2. Principles of Nanophotonics, Motoichi Ohtsu, et al. Taylor & Francis Group, LLC (2008)
3. Advances In Biophotonics, (Eds.) Brian C. WilsonValery V. Tuchin and Stoyan Tanev, IOS Press, (2005).
4. Biophotonics, Optical Science and Engineering for the 21st Century, (Ed.) Xun Shen and Roeland Van Wijk,
5. NANO BIOPHOTONICS: Science and Technology, (Eds) Hiroshi Masuhara, Satoshi Kawata and Fumio Tokunaga, Elsevier (2007).

NAST-828: Advanced Nanobiotechnology

Unit –I **(9 hrs)**

Synthetic Materials in Medicine, roperties of Materials: Bulk Properties of Materials, Surface Properties of Materials. Classes of Materials Used in Medicine: Structure and Properties of Metals, Ceramics, Glasses, and Glass-Ceramics, Polymers, Hydrogels, Family of Carbon Nanomaterials, Bioresorbable and Bioerodible Materials, Composites, Thin Films, Grafts and Coatings, Biologically Functional Materials.

Unit –II **(9 hrs)**

Biological Interactions with Materials

Introduction, Biocompatibility, Toxicity, Cytotoxicity, Hypersensitivity, Carcinogenicity, Interaction of Materials with Soft Tissues, Inflammation, Granulation Tissue Formation, Foreign Body Reaction, Fibrosis, Modification of Blood-Biomaterial Interactions, Interaction with Blood by Heparin, Interactions with Proteins, Cell Adhesion, Interactions with Hard Tissues, The Vroman Effect, Adhesion of Osteoblasts, Osseointegration, Fibrous Capsule Formation, Safety Testing of Biomaterials.

Unit –III **(9 hrs)**

Nanotoxicology

Introduction, Toxicity of nanoparticles, Types of Nanoparticles causing Toxicity, Target organ toxicity, Exposure, Uptake, and Barriers, Experimental Models in Nanotoxicology - In vitro Models, In Vivo Models, Predicting Penetration and Fate of Nanoparticlesin the Body, Toxicity Mechanisms - Mechanisms for Radical Species Production, General Genotoxicity Mechanisms, Detection and Characterization of Genotoxicity.

Unit –IV **(9 hrs)**

Tissue engineering

Introduction, Stem cells, Morphogenesis, Generation of tissue in the embryo, Tissue homeostasis, Cellular signaling, Extracellular matrix as a biologic scaffold for tissue engineering, Natural polymers in tissue engineering applications, Degradable

polymers for tissue engineering, Degradation of bioceramics.Cell source, Cell culture: harvest, selection, expansion, and differentiation, Cell nutrition, Cryobiology, Scaffold design and fabrication, Controlled release strategies in tissue engineering

Unit –V **(9 hrs)**

Drug Delivery Systems

Fundamentals of Drug Nanoparticles: Production, Size, Surface area, Suspension and Settling, Magnetic and Optical Properties, Biological Transport. Manufacturing of Nanoparticles: Ball-Milling, High-Pressure Homogenization, Spray-Drying Production in Nonaqueous Liquids, Hot-Melted Matrices, Pelletization Techniques, Direct Compress. Delivery of Nanoparticles: Brain Delivery, Ocular Drug Delivery, Gene Delivery Systems, Carriers in Cancer Therapy, Cardiovascular System, Vascular Delivery to the Lungs, Targeting Lymphatics.

TEXT BOOKS

1. BlOMATERIALS SCIENCE, An Introduction to Materials in Medicine, Edited by Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Academic Press, A division of Harcourt Brace & Company, 525 B Street, Suite 1900, San Diego, California 92101-4495, USA.
2. The Chemistry of Medical and Dental Materials, John W. Nicholson, RSC MATERIALS MONOGRAPHS, Published by The Royal Society of Chemistry, Thomas Graham House, Science Park, Milton Road, Cambridge CB4 OWF, UK. ISBN 0-85404-572-4.
3. Tissue Engineering, Clemens van Blitterswijk, Peter Thomsen, Anders Lindahl, Jeffrey Hubbell, David Williams, Ranieri Cancedda, Joost de Bruijn, Jérôme Sohier, Academic Press, Elsevier, 84 Theobald's Road, London WC1X 8RR, UK, 30 Corporate Drive, Suite 400, Burlington, MA 01803, USA, 525 B Street, Suite 1900, San Diego, CA 92101-4495, USA, 2008 ISBN: 978-0-12-370869-4.
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NAST-828: Any other courses offered by the Centre/Other Departments at M.Tech level to be suggested by the Doctoral Committee.

NAST- 820: Research Seminar

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