



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

2022-2023 ONWARDS

Ph.D. - Nanoscience and Technology Programme

Syllabus (2022-23 Onwards)

Part- I

Code No.	Subject	Course Type	Class hours	University Examination			Credit
				Internal	External	Total	
NAST-921	Research Methodology for Nanoscience and Technology	HC	3	40	60	100	3
SPECIFIC AREA OF RESEARCH PAPER (Any one to be suggested by the Doctorial Committee)							
NAST-922	Nanostructured Materials for Clean Energy Systems	SC	3	40	60	100	3
NAST-923	Polymers and Nanocomposites	SC	3	40	60	100	3
NAST-924	Industrial Nanotechnology	SC	3	40	60	100	3
NAST-925	Nanomagnetic materials and devices	SC	3	40	60	100	3
NAST-926	Surface Engineering in Nanotechnology	SC	3	40	60	100	3
NAST-927	Nano-photonics and Biophotonics	SC	3	40	60	100	3
NAST-928	Advanced Nanobiotechnology	SC	3	40	60	100	3
NAST-9XX	Any other courses offered by the Centre /Other Departments/ Any new course suggested by Research supervisor/ DC members at M.Sc./M.Tech level.	SC	3	40	60	100	3
NAST-930	Research and Publication Ethics (RPE)	HC	2	40	60	100	2

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

Candidates with M.Tech/ M.Phil are exempted from taking the Part - I examinations. However, NAST-930 (Research and Publication Ethics) course is compulsory for all Ph.D scholars as per the new Ph.D regulations of the University.

Other candidates (without M.Tech/M.Phil.) should complete the Part-I examinations, within two years from the date of registration, in consultation with the Doctoral Committee. Two courses NAST-921 & NAST-930 are compulsory for them. The third compulsory paper is a specific research area paper at the M.Sc./M.Tech level, and this paper will be suggested by the Doctoral Committee.

The Part-I examination will be conducted by the Supervisor/HoD (as per the University policy). The supervisor will communicate the results through the HoD/Dean to the CoE. The evaluation of Part-I papers will be done by the supervisor/Teacher who offered the course. The passing minimum for each of the Papers shall be 55% marks. Each Paper of the Ph.D. coursework shall be with a minimum of 3 credits. **The course work shall have total a minimum credits of 8 to qualify in Part-I examinations.**

Part-II is the Confirmation of provisional registration and the submission of the thesis under the guidance of the Research Supervisor.

Eligibility for Ph.D. Admission:

- M.E./M.Tech in Nanoscience and Technology / Nanotechnology / Nano-Electronics / Nano-Biotechnology/ Nano-Medicine/ Electrical, Electronics, Instrumentation, Chemical, Mechanical, Metallurgical, Bio-Medical or Environmental Engg., / Materials Science & Engg., / Polymer Science & Engg., / Energy Technology and other relevant subjects with a minimum of 55% of marks. (OR)
- Masters degree in Nanoscience and Technology/ Physics / Chemistry /Applied Physics / Applied Chemistry/ Materials Science / Environmental Sciences / Biotechnology / Bio-Chemistry with a minimum of 55% of marks.

Syllabus for Courses

NAST- 921: 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, Porous materials, Quantum dot (QDs) synthesis, self-assembly of nanostructures.

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), Thermogravimetric Analysis (TGA), TEM, X-ray Photoelectron Spectroscopy (XPS), ICP-AES chemical analysis, Electrochemical Characterization measurements, particle size analyzer.

UNIT-IV (9 hrs)

Physical Properties of Nanostructured Materials

Size effect of Nanomaterials: Size, shape, density, melting point, wettability and specific surface area. Electronic properties: Electronic conductivity, band gap tuning - band gap determination – Piezoelectric and ferroelectric materials and their behaviour and applications. Magnetic properties: Magnetic hysteresis – Superparamagnetism - Optical properties: Electroluminescence, Photoluminescence, Jablonski diagram, fluorescence and phosphorescence, Optical properties of nanostructures.

UNIT- V (9 hrs)

Intellectual property and 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 products.

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, Addison 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 course to be suggested by the Doctoral Committee)

NAST-922: 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, Hydrogen generation & Storage, 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 photovoltaic Cells, Physics of photovoltaic cells, Organic photovoltaic cell cells, thin film Dye Sensitized Solar Cells, Quantum dot (QD) Sensitized Solar Cells (QD-SSC), Perovskite solar cells, Organic-Inorganic Hybrid Bulk Hetero Junction (BHJ-SC) Solar cells, Solar-water splitting, 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, redox-flow batteries for HEV/EV transportation and stationary applications, 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, porous 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 Academic Publishers, Dordrecht, Netherlands (2004).
4. J. Larminie 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).
4. Photoelectrochemical hydrogen generation, theory, materials advances, and challenges, by Pooja Devi, Springer Publications 2022, ISBN: 978-981-16-7285-9
5. Redox flow batteries, Fundamentals and applications by Zhang Huamin, CRC Press publications, ISBN: 9781498753944

NAST-923: Polymers and Nanocomposites**UNIT-I (9 hrs)**

Elements of Polymer Science: 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, the importance of Tg, the relationship between Tm and Tg and their control; **Crystallinity in polymers:** Degree of crystallinity, factors affecting crystallinity of polymers, the 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)

Speciality polymers: Synthesis of aromatic polyethers, polyacetals, polyamides, polyurethane, polymers with metal in their backbone, P and S containing polymers, Bio-polymers, Bio-degradable polymers, Fire retardant polymers, Liquid crystalline polymers - **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 - Thermal analysis of polymers using DSC, TGA, DTA, and DMA.

UNIT-III (9 hrs)

Conducting Polymers: Discovery – Conducting mechanism – Classification of conducting polymers: Intrinsic and extrinsic conducting polymers - Chemical and electrochemical methods for the synthesis of conducting polymers – Applications of conducting polymers in corrosion protection, electrochemical energy devices and sensors,.

UNIT-IV (9 hrs)

Nanocomposites: Introduction to Nanocomposites, Types of Nanocomposites - Methods for producing Nanocomposites – Properties of Nanocomposites.

Polymer Nanocomposites: Polymer/ Metal oxide nanocomposites - Polymer/CNTs nanocomposites - Polymer/Nanoclay-based Nanocomposites 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 and its designing and improvements in mechanical properties - Self-cleaning nanocomposites; Metal matrix nanocomposites: Metal with nanoceramic fillers such as TiO₂, SiC, ZrO₂ PTFE, CNTs and Graphene 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.
6. A.J.Bard & L.R.Faulkner, Electrochemical methods-Fundamentals and Applications John Wiley & Sons, 3rd Edition, 2001.

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.
5. Yiu-Wing Mai and Zhong –Zhen Yu, Polymer-Nanocomposites, CRC Press, 2006.
6. E.Raub &K.Muller, Fundamentals of Metal deposition, Elseiver publishing Co, New York, 1967.

NAST -924: Industrial Nanotechnology

UNIT- I (9 hrs)

Nanotechnology in Agriculture and Food Industries

Agriculture industry: - Precision farming, Smart delivery system – Insecticides using Nanotechnology – Nano fertilizers -Nanofertigation - Nano-seed Science.

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- II (9 hrs)

Nanotechnology in Textiles and Cosmetics Industries

Textiles Industry: Production of Nano-woven fibers from electrospinning – Controlling parameters and morphologies of nanofibers – Nanocomposite 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.

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

UNIT-III (9 hrs)

Nanotechnology in Chemical and Electrochemical Industries

Nanocatalysts – Smart Materials – Nanostructures for molecular recognition (0D, 1D and 2D) – Molecular encapsulation and its applications – Nanoporous Zeolites – Nano-reactors – Solid lubricants – Nanotechnology in Electrometallurgy, Electroplating industry and Corrosion protective organic coatings – Electrolytic production of metal nanopowders, Electrochemical exfoliation for the production of Graphene and other metal chalcogenides – Electrochemical preparation of Nanostructured conducting polymers.

UNIT-IV (9 hrs)

Nanotechnology in Defence

Military applications of Nanotechnology –Nano-Battle suit – Nano-drones – Nano- Satellites – Nano-Propellants and Explosives – Camouflage distributed sensors - Amour protection - Implanted Nano-systems - Mini-/Micro robots - Small satellites and Space launchers –Nano- Nuclear, Chemical and Biological weapons - Chemical/Biological protection.

UNIT- V (9 hrs)

Nanotechnology in Environmental and Health Effects

Overview of physical, chemical, and biological processes concerning the environment- Nanomaterial based adsorbents and photocatalysts for water and wastewater treatment – Nanomaterials for adsorption of heavy metals – Nanoparticles for degradation of organic and organic compounds – Treatment of Arsenic using Nano TiO₂ and other nanoparticles – Nanomembranes in drinking water purification and desalination – Environmental impacts of Nanomaterials on human and animal health – Safety issues and regulatory practices in handling Nanomaterials – Environmental hazard in processing of Nanomaterials – Emerging issues of nano/microplastics - Green synthesis/zero-waste processes.

TEXTBOOKS

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, WillehmNorde, 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).
- 8.M.R. Rifi and F.H.Covitz, Industrial Electrochemistry, Marcel Dekker Inc, New York, 1974.
- 9.K.I.Popov, S.S.Djokic and B.N.Grgur, Fundamentals of Electrometallurgy, Kluwer Academic Publishing 2002.
- 10.A.J.Bard & L.R.Faulkner, Electrochemical methods-Fundamentals and Applications John Wiley & Sons, 3rd Edition, 2001.

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.
4. .E.Raub &K.Muller, Fundamentals of Metal deposition, Elseiver publishing Co, New York, 1967.

NAST-925: 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-926: 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, Rabinowicz, 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. Harald Ibach, 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 Science and Technology- From concepts to applications, Second Edition, CRC Press, Boca Raton, 2009
5. B. Bhushan, 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, Nanoparticles and catalysis, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2008.
3. Ryan Richards, Surface and Nanomolecular Catalysis, Taylor & Francis, Boca Raton, 2006.
4. Jeremy Ramsden, Biomedical Surfaces, Aptech House, Inc., Boston, 2008.
5. Renate Forch, Holger Schonherr, and A. Tobias A. Jenkins, Surface Design: Applications in Bioscience and Nanotechnology, Wiley -VCH Verlag GmbH & Co. KGaA, Weinheim, 2009

NAST-927: Nanophotonics and Biophotonics

UNIT-I

(10 hrs)

Introduction to photonics

Electromagnetic properties of nanostructures – Wavelength and Dispersion laws – Density of states – Maxwell's 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 In vitro Bioanalysis - Nanoclinics for optical diagnostics and Targeted therapy.

UNIT-V**(8 hrs)****Biomaterials for Photonics**

Photonics and Biomaterials – Bioderived materials (Bacteriorhodopsin, 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. Sibia, 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-928: 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 Nanoparticles in 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. BIOMATERIALS 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 0WF, 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.
4. Nanofabrication towards Biomedical Applications, Techniques, Tools, Applications, and Impact. C. S. S. R. Kumar, J. Hormes, C. Leuschner, 2005, WILEY -VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN-13 978-3-527-31115-6, ISBN-10 3-527-31115-7.

5. Nanoscale Technology in Biological Systems, Edited by Ralph S. Greco, Fritz B. Prinz, R. Lane Smith, CRC PRESS, Boca Raton London New York Washington, D.C. Copyright © 2005 by Taylor & Francis
6. Nanoparticulates Drug Carriers, Edited by VLADIMIR P TORCHILIN, 2006, Imperial College Press, 57 Shelton Street, Covent Garden, London WC2H 9HE, ISBN 1-86094-630-5

REFERENCE BOOKS

1. Nanoparticle Technology for Drug Delivery. Edited by Ram B. Gupta, Uday B. Kompella, 2006, Taylor & Francis Group, 270 Madison Avenue, New York, NY 10016.
2. Biological Nanostructures and Applications of Nanostructures in Biology. Electrical, Mechanical, and Optical Properties. Edited by Michael A. Stroschio and Mitra Dutta, 2004, Kluwer Academic Publishers, New York, Boston, Dordrecht, London, Moscow, eBook ISBN: 0-306-48628-8, Print ISBN: 0-306-48627-X
3. BIOMEDICAL NANOSTRUCTURES. Edited by Kenneth E. Gonsalves, Craig R. Halberstadt, Cato T. Laurencin, Lakshmi S. Nair, Wiley-Interscience A John Wiley & Sons, Inc., Publication, 2008.
4. Dendrimer based Nanomedicine, Edited by Istvan J. Majoros, James R. Baker, 2008, Pan Stanford Publishing Pte. Ltd.
5. Nanoparticulate Drug Delivery Systems, Edited by Deepak Thassu, Michel Deleers, Yashwant Pathak, 2007, Informa Healthcare USA, Inc., 270 Madison Avenue, New York, NY 10016, ISBN-13: 978-0-8493-9073-9.

NAST- 930: Research and Publication Ethics (RPE)

THEORY

Unit – 01 : Philosophy and Ethics (3 hrs.)

Introduction to philosophy: Definition, nature and Scope, concept, branches; Ethics: Definition, moral philosophy, nature of moral judgements and reactions.

Unit – 02 : Scientific Conduct (5hrs.)

Ethics with respect to science and research; Intellectual honesty and research integrity; Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP); Redundant publications: duplicate and overlapping publications, salami slicing; Selective reporting and misrepresentation of data.

Unit – 03 : Publication Ethics (7 hrs.)

Publication ethics: Definition, introduction and importance; Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.,; Conflicts of interest; Publication misconduct: definition, concepts, problems that lead to unethical behavior and vice versa, types; Violation of publication ethics, authorship and contributor ship; Identification of publication misconduct, complaints and appeals; predatory publishers and journals.

PRACTICE

Unit – 04 : Open access Publishing (4 hrs.)

Open access publications and initiatives; SHERPA/RoMEO online resources to check publisher copyright & self-archiving policies; Software tool to identify predatory publications developed by SPPU; Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer journal Suggester, etc.

Unit – 05 : Publication Misconduct (4 hrs.)

Group Discussions (2 hrs.): Subject specific ethical issues, FTP, authorship; Conflicts of interest; Complaints and appeals: Examples and fraud from India and abroad. Software tools (2 hrs.): Use of plagiarism software like Turnitin, Urkund and other open source software tools.

Unit – 06 : Databases and Research Metrics (7 hrs.)

Databases (4 hrs.): Indexing databases; Citation databases: Web of Science, Scopus, etc. Research Metrics (3 hrs.) Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g index, i10 index, altmetrics

References:

1. Bird,A.(2006).Philosophy of science .Routledge.
2. MacIntyre,Alasdair(1967) A Short History of Ethics. London.
3. P.Chaddah,(2018) Ethics in Competitive Research: Do not get Scooped; do not get plagiarized,ISBN:978-9387480865

4. National Academy of Sciences, National Academy of Engineering and Institute of Medicine (2009). On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition. National Academies Press.
5. Resnik, D.B. (2011). What is ethics in research & why it is important. National Institute of Environmental Health Sciences, 1-10. Retrieved from <http://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm>
6. Beall, J. (2012). Predatory Publishers are corrupting open access. Nature, 489(7415), 179-179. <http://doi.org/10.1038/489179a>
7. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019), ISBN: 978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf

NAST-9XX: Any other courses offered by the Centre / Other Departments at M.Tech level / Any new course suggested by Research supervisor/DC members.
