Ph.D - Nanoscience and Technology Programme

Syllabus & Regulations

2016-17 ONWARDS
# Ph.D. - Nanoscience and Technology Programme

**Syllabus (2016-17 Onwards)**

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

*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.

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 borohydride reduction methods, Sol-Gel synthesis; Microemulsions synthesis, Hydrothermal, Solvothermal synthesis methods, Microwave assisted synthesis; Sonocatalytic 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

UNIT- IV  (9 hrs)
Physical Properties of Nanostructured Materials

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, copyright 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**

**REFERENCE BOOKS**

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

UNIT-IV (9 hrs)
Nanomaterials for Energy Storage (Batteries) Systems

UNIT-V (9 hrs)
Nanomaterials for Energy Storage (Capacitor) Systems

TEXTBOOK

REFERENCE BOOK

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)

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, CeO₂, TiO₂, ZrO₂ PTFE, CNTs and their mechanical, corrosion resistance properties and functional applications.

TEXT BOOKS

REFERENCE BOOKS
1. George Odian, Principles of Polymerization, John Wiley & Sons, 1933

NAST -824: Industrial Nanotechnology

UNIT-I
(9 hrs)

Nanotechnology in Electrical and Electronics Industry

UNIT-II
(9 hrs)

Nanotechnology in Textiles and Cosmetics
UNIT- III
Nanotechnology in Defence

UNIT- IV
Nanotechnology in Agriculture and Food Technology
Nanotechnology in Agriculture - Precision farming, Smart delivery system – Nanofertilizers: Nanourea and mixed fertilizers, Nanofertigation - Nanopesticides, Nanoseed 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
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

REFERENCE BOOK
NAST-825: Nanomagnetic Materials and Devices

UNIT-I
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
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
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 granules, Coulomb blockade in tunnel junctions.

UNIT-IV
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
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
REFERENCE BOOKS
1. Magnetism in the solid state, P. Mohn, Springer series in the solid state, sciences,

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

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
Tribological Aspects of Surfaces
(9 hrs)

UNIT-V
Surfaces in Multidisciplinary Applications
(9 hrs)

TEXT BOOKS

REFERENCE BOOKS
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**  
*Introduction to photonics*  

**UNIT-II**  
*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**  
*Photobiology*  

**UNIT-IV**  
*Nanotechnology for biophotonics*  

**UNIT-V**  
*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**  
REFERENCE BOOKS
4. Biophotonics, Optical Science and Engineering for the 21st Century, (Ed.) Xun Shen and Roeland Van Wijk,

NAST-828: Advanced Nanobiotechnology

Unit –I (9 hrs)

Unit –II (9 hrs)
Biological Interactions with Materials

Unit –III (9 hrs)
Nanotoxicology

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

TEXT BOOKS
REFERENCE BOOKS

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