Group No.	Course Code	Course Title	Unique Code
1	20INT12	Quantum Mechanics for Nanostructures	201NT001
1	20INT13	Nanomaterials and Properties	201NT002
1	20INT241	Nanotechnology and Environment	201NT003
1	20INT243	Nanobiotechnology	201NT004
2	20INT14	Synthesis and Processing Techniques	202NT001
2	20INT251	Nanoelectronics	202NT002
2	20INT252	MEMS and NEMS	202NT003
2	20INT253	Industrial Applications of Nanotechnology	202NT004
3	20INT22	Characterization Techniques	203NT001
3	20INT323	Micro and Nanofluidics	203NT002
3	20INT254	Nanotechnology in Civil Engineering	203NT003
3	20INT244	Surface Engineering of Nanomaterials	203NT004
4	20INT321	Modeling and Simulation in Nanotechnology	204NT001
4	20INT322	Nanotechnology in Diagnostics and Drug Delivery	204NT002
4	20INT23	Advanced & Smart Materials	204NT003
4	20INT324	Nanotechnology for corrosion Science and Engineering	204NT004
5	20INT331	Nanobioelectronics and Applications	205NT001
5	20INT332	Micro-Nano Packaging	205NT002
5	20INT333	Advances in Nanodevices	205NT003
5	20INT334	Nanotechnolgy in Food and Agriculture	205NT004
6	20INT15	Carbon Based Nanostructures	206NT001
6	20INT31	Nanomaterials and Energy Systems	206NT002
6	20INT21	Design and Fabrication Techniques	206NT003
6	20INT242	Nanocomposites and its applications	206NT004

Visvesvaraya Technological University, Belagavi.
Ph.D Coursework Courses – 2020 in Nanotechnology

Ph.D Coursework Courses under Group - 1			
SlNo	**Course Code**	**Course Name**	**Page**
1	20INT12	Quantum Mechanics for Nanostructures	
2	20INT13	Nanomaterials and Properties	
3	20INT241	Nanotechnology and Environment	
4	20INT243	Nanobiotechnology	

Ph.D Coursework Courses under Group - 2			
SlNo	**Course Code**	**Course Name**	**Page**
1	20INT14	Synthesis and Processing Techniques	
2	20INT251	Nanoelectronics	
3	20INT252	MEMS and NEMS	
4	20INT253	Industrial Applications of Nanotechnology	

Ph.D Coursework Courses under Group - 3			
SlNo	**Course Code**	**Course Name**	**Page**
1	20INT22	Characterization Techniques	
2	20INT323	Micro and Nanofluidics	
3	20INT254	Nanotechnology in Civil Engineering	
4	20INT244	Surface Engineering of Nanomaterials	

Ph.D Coursework Courses under Group - 4			
SlNo	**Course Code**	**Course Name**	**Page**
1	20INT321	Modeling and Simulation in Nanotechnology	
2	20INT322	Nanotechnology in Diagnostics and Drug Delivery	
3	20INT23	Advanced & Smart Materials	
4	20INT324	Nanotechnology for corrosion Science and Engineering	

Ph.D Coursework Courses under Group - 5			
SlNo	**Course Code**	**Course Name**	**Page**
1	20INT331	Nanobioelectronics and Applications	
2	20INT332	Micro-Nano Packaging	
3	20INT333	Advances in Nanodevices	
4	20INT334	Nanotechnolgy in Food and Agriculture	

Ph.D Coursework Courses under Group - 6			
SlNo	**Course Code**	**Course Name**	**Page**
1	20INT15	Carbon Based Nanostructures	
2	20INT31	Nanomaterials and Energy Systems	
3	20INT21	Design and Fabrication Techniques	
4	20INT242	Nanocomposites and its applications	

(Group-1):20INT12**Quantum Mechanics for Nanostructures**	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction

Milestones in nanoscience and nanotechnology, Nanostructures and quantum physics, Layered nanostructures and superlattices, Nanoparticles and nanoclusters, Carbon-based nanomaterials. Wave-particle duality: Blackbody radiation, interaction of radiation with matter, photoelectric effect, Compton effect, wave-particle duality, De-Broglie's hypothesis, uncertainty relations, wave function, Schrodinger equation, Operators.

Module-2

Solutions of Schrodinger Equations

One-dimensional potential: Free electron in vacuum, electron in a potential well with infinite barriers, finite barriers and propagation of an electron above the potential well, Tunnelling: propagation of an electron in the region of a potential barrier. Three-dimensional potential: Electron in a rectangular potential well (quantum box) and spherically-symmetric potential well, Quantum harmonic oscillators, Phonons.

Module-3

Approximate methods of finding quantum states:

Stationary perturbation theory for a system with non-degenerate states and degenerate states. Non-stationary perturbation theory, quasi-classical approximation.

Module-4

Quantum states in atoms and molecules:

Quantum states in hydrogen atom, emission spectrum, spin of an electron. Many-electron atoms: wave function of a system of identical particles, hydrogen molecule.

Module-5

Quantization in nanostructures:

Number and density of quantum states, low-dimensional structures, Quantum states of an electron in low-dimensional structures, density of states for nanostructures, Double-quantum-dot structures (artificial molecules), electron in a periodic one-dimensional potential, one-dimensional superlattice of quantum dots, three-dimensional superlattice of quantum dots.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Quantum Mechanics for Nanostructures	Vladimir V. Mitin, Dmitry I. Sementsov, Nizami Z. Vagidov	Cambridge University Press	2010
2	Quantum Mechanics with applications to nanotechnology and information science	Yehuda B. Band, YshaiAvishai.	Elsevier	2013
3	Handbook of theoretical and computational Nanotechnology	eds. Michael Rieth and Wolfram Schommers,		2006

4	Computational physics,	R. C. Verma, K. C. Sharma & P. K. Ahluwalia		
5				

(Group-1): 20INT13 NANOMATERIALS AND PROPERTIES

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction to nanoscience and nanotechnology:
History, background scope and interdisciplinary nature of nanoscience and nanotechnology, scientific revolutions. Definition of Nanometer, Nanomaterials, and Nanotechnology. Concepts of nanotechnology - size dependent phenomena, surface to volume ratio, atomic structure, molecules and phases, energy at the nanoscale molecular and atomic size. Misnomers and misconception of nanotechnology, importance of nanoscale materials and their devices.

Module-2

Classification of Nanostructures:
Zero dimensional, one-dimensional and two dimensional nanostructure materials. Clusters of metals, semiconductors, ceramics and nanocomposites. Size effect on shapes, Quantum dots, Nanorods, nanowires, nanotubes, nanosheets, nanocones, Nanotetrapods, Nanoflowers, nanobrushes, nano and mesopores, Core-Shell nanoparticles.

Module-3

Types of Nanomaterial:
Metal nanoparticles, Ceramics nanomaterials, Semiconductor nanoparticles, Metal oxides nanoparticles, Carbon based nanostructures. Acomparison with respective bulk materials; Organic semiconductors Importance of these nanomaterials and their applications.

Module-4

Properties of Nanomaterials:
Mechanical properties, Nano size effect on strength, fracture toughness and fatigue behaviour. Bulk Properties of Materials, electrical conductivity, Dielectric properties, Thermal properties, thermal conductivity, heat capacity. Magnetic properties, Magnetic materials, domains in Magnetic materials.

Module-5

Electronic and Optical Properties:
Electronic structure of Nanomaterials, magic numbers, Fermi surface, Size effect on Electron-Phonon Coupling, Size effect on physical properties. Optical properties, Optoelectronic properties of bulk and nanostructures, relation between optical properties and electronic structure of nanomaterials – Catalytic property Catalysis by Gold Nanoparticles

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year

1	Nanophysics and Nanotechnology - An Introduction to Modern Concepts in Nanoscience	Edward L. Wolf	Second Edition, John Wiley & Sons	2006
2	Nanoscience and Nanotechnology: fundamentals to Frontiers	M.S. Ramachandra Rao, Shubra Singh	Wiley	2013
3	Nanostructures and Nanomaterials synthesis, properties and applications	g. Cao	Imperial College press	2004
4	Nanoparticle Technology Handbook,	Masuo Hosokawa, Kiyoshi Nogi, Makio Naito, Toyokazu Yokoyama	Elsevier Science,	2007
5	Nanotechnology – Basic Science & Emerging Technologies,		Chapman & Hall/CRC	2002

(Group-1): 20INT241NANOTECHNOLOGY AND ENVIRONMENT

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Environmental Application of Nanomaterials

Metal oxide nanoparticles organic contamination remediation, Nano active materials, Advanced photocatalyst, removal organic contamination from waste water using Nanomaterials based photocatalyst. Nanostructure electrode for Electrochemical oxidation.

Module-2

Nanostructure catalytic materials

Nanostructured metals like Pt, Pd and Fe, nanostructured ceramics like silica, silicate and alumina, pillared clays, colloids and porous materials. Nanomaterials as catalyst for exhaust gas treatment such as CO_2, H_2S, Pb, NO.

Module-3

Nanomaterials as Adsorbents

Meosoporous materials-synthesis and characterization, properties and application with suitable examples, unipore size, bimodal pore size. Nanoporous materials- synthesis and application. Adsorption at the Oxide Nanoparticles/Solution Interface, Nanomaterial-Based Removal of nanoparticles-Principle of particle removal - Removal of nanoparticles suspended in gas - Removal of nanoparticles in liquid. Adsorption of hazardous chemicals by metal oxide nanoparticles, Adsorption of chemical warfare agents by metal oxide nanoparticles. Nanomaterials as adsorbents for Heavy metal removal from water and Wastewater Treatment, Nanomaterials for Groundwater Remediation- Reactivity, Fate, and Lifetime Delivery and Transport Issues.

Module-4

Nanotoxicology

Health effects on nanoparticles - Inhalation of nanomaterials–overview, Nanoparticle exposure and systematic cardiovascular effects. Respiratory particulate matter exposure and cardiovascular toxicity, Toxicity of different nanomaterials, Toxicological assessment of nanoparticles: Toxicity of polymeric nanoparticles. Eco-toxicological Impacts of Nanomaterials. Nanoparticles in atmospheric environment, Ground water environments, Waste water and in exhaust gases - Industrial processes and nanoparticles. Safety of nanoparticles- Problems caused by nanoparticles - Safety assessment for the nanoparticles.

Module-5

Cleanroom basics, hazards, and safety

Basics of cleanroom classification and ISO standards, sources of particulate contamination, clean air devices, special construction materials for cleanroom, and surface finishes. The HEPA filters and filtration process in the clean rooms. Parameters control in cleanrooms: temperature, RH, air volume and velocity, pressurization, and differential pressure. Potential hazards in cleanrooms: Fire, explosions, toxicity, and physical hazards. Cleanroom operational and behavioural requirement. Material handling issues: DI water, solvents, cleaners, ion implantation sources, diffusion sources, photoresists, developers, metals, dielectrics, toxic gases, flammable, corrosive, and packaging materials. Types of cleanroom waste: handling and disposal of chemical, biological, infectious, radioactive, and mixed waste.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Environmental Applications of Nanomaterials: Synthesis, Sorbents and Sensors	Glen E. Fryxell, Guozhong Cao		
2	Environmental Nanotechnology: Applications and Impacts of Nanomaterials	Mark R. Wiesner, Jean-Yves Bottero		
3	Biomaterials Science and Engineering	J. B Park	Plenum Press, New York,.	1984
4	Nanotechnology - Toxicological Issues and Environmental Safety	P.P. Simeonova, N. Opopol and M.I. Luster	Springer	2006
5	Encyclopedia of Nanoscience and nanotechnology	J.J. Davis, Dekker		

(Group-1): 20INT243Nanobiotechnology

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Fundamentals of Biotechnology

Basic terms in biotechnology, recombinant DNA technology, genetic engineering, gene cloning. Development of nanobiotechnology, timelines and progress. Basics of cell orgenells. Biomacromolecules- carbohydrates, lipids, proteins and nucleic acids, PHA, cyanophcin inclusion, magnetosome, alginates, bacteriophages, S-layer protein, bacteriorhodpsin. Biological building blocks; Sizes of building blocks and comparison with nanostructures.

Module-2

Nanostructures:

DNA and protein based nanostructures, DNA origami, DNA nanotubes, polypeptide nanowire and protein nanoparticles, SAM, biological nanomotor. Nanoconjugates: DNA-gold nanoconjugates. DNA based nanoelectronics: immobilization of DNA on substrates, probing the electronic properties of single DNA molecules. Manipulation of DNA on metal surfaces.

Module-3

Interaction between biomolecules and nanoparticle surface

Different types of inorganic materials used for the synthesis of hybrid nano-bio assemblies, Application of nano in biology, nanoprobes for Analytical Applications - A new methodology in medical diagnostics and Biotechnology, Current status of Nanobiotechnology, Future perspectives of Nanobiology.

Module-4

Applications of nanomaterials

Drug delivery and gene delivery, Nanobiochips, biosensors. Nanomaterials in bone substitutes and dentistry. Polymeric nanofibres-tissue engineering, smart capsules, microemulsions, nano based cancer therapy, nanorobotics. Lotus leaf as a model self-cleansing system. Diatoms as example for silicon biomineralization. Biomechanical strength properties of Spider silk.

Module-5

Photoinduced Electron Transport in DNA

Electronic Devices Based on DNA Architecture, DNA Nanowires, Charge Transport, DNA-Based Nanoelectronics, Electrical Manipulation of DNA on Metal Surfaces, Nanostructured Bio-compartments, DNA-Gold nanoconjugates.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Nanobiotechnology: Bioinspired devices and materials of the future	OdedShoseyov, Ilan Levy.	Humana Press	2010
2	Bionanotechnology - Global Prospects	David E. Reisner,	Taylor & Francis Group, LLC,	2009
3	Nanotechnology in Drug Delivery	Melgardt M.deVilliers, PornanongAramwit, Glen S. Kwon	Springer-American Association of Pharmaceutical Scientists Press	2009
4	NANO The Essential , understanding Nanoscience and Nanotechnology".	T. Pradeep	Tata McGraw-Hill Publishing Company Limited	2007
5	Nanotoxicology: Characterization, Dosing and Health Effects	Nancy A. Monteiro-Riviere, C. Lang Tran	CRC Press	July 25 2007

(Group-2): 20INT14 Synthesis and Processing Techniques	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Physical Methods:

Bottom-Up versus Top-Down; Top-down approach with examples. Ball milling synthesis, Arc discharge, RF-plasma, Plasma arch technique, Inert gas condensation, electric explosion of wires, Ion sputtering method, Laser pyrolysis, Molecular beam epitaxy and electrodeposition. Electro spinning, Physical Vapor Deposition (PVD) – Chemcial Vapour Deposition (CVD) - Atomic layer Deposition (ALD) – Self Assembly- LB (Langmuir-Blodgett) technique.

Module-2

Chemical methods:

Chemical precipitation methods- Coprecipitation, Arrested precipitation, Sol-gel method, Chemical reduction, Photochemical synthesis, Electrochemical synthesis, Microemulsions or Reverse Micelles, Sonochemical synthesis, Hydrothermal, Solvothermal, Supercritical fluid process.

Module-3

Combustion and Solution Methods:

Solution combustion process, spray pyrolysis method, flame spray pyrolysis, gas phase synthesis, gas condensation process, chemical vapour condensation. Fundamental aspects of VLS (Vapour-Liquid-Solid) and SLS (Solution-Liquid-Solid) processes – VLS growth of Nanowires – Control of the size of the nanowires – Precursors and catalysts – SLS growth – Stress induced recrystallization.

Module-4

Biological methods:

Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Natural and artificial synthesis of nanoparticles in microorganisms; Use of microorganisms for nanostructure formation, Role of plants in nanoparticle synthesis, synthesis of nanoparticles using proteins and DNA templates.

Module-5

Surface Modification of Nanoparticles

Introduction to Nanoparticles dispersion and aggregation behaviour, Surface interaction between nanoparticles, Difficulty in nanoparticle control based on DLVO theory. Effect of particle diameter and solid fraction on distance between the particle surface, Surface molecular level structure of Nanoparticles. Basic approach to control nanoparticle dispersion behaviour. Surface modification of inorganic nanoparticles by organic functional groups –Organic modification of Metal, Metal oxide nanoparticles, hybridization of inorganic nanoparticles with biomolecules. Surface modification of Carbon Nanostructures.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Nanostructures and Nanomaterials, synthesis, properties and applications	Guozhong Cao	Imperial College Press,	2004

2	Nanoscience and Nanotechnology: fundamentals to Frontiers,	M.S. Ramachandra Rao, Shubra Singh	Wiley	2013
3	Introduction to Nanotechnology		Charles P. Poole Jr. and Franks. J. Qwens	
4	Nanomaterials	A. K. Bandyopadhyay,	New Age International Publishers, 2nd Edition	2010
5	NANO The Essential , understanding Nanoscience and Nanotechnology	T. Pradeep	Tata McGraw-Hill Publishing Company Limited	2007

(Group-2): 20INT251Nanoelectronics	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction to Nanoelectronics

Technology roadmap of nano-electronics, Scaling of devices and technology jump, Challenge of the CMOS technologies, More-Moore and More-than-Moore. Review of semiconductor devices, Quantum statistical mechanics, Energy bands in silicon, **Metal Oxide Semiconductor Field Effect Transistors (MOSFET),** MOSFET Operation, Threshold Voltage and Subthreshold Slope, Current/voltage characteristics, Finite Element Modeling of MOS, CMOS technology, Challenges of the CMOS technologies, High-k dielectrics and Gate stack, Future interconnect.

Module-2

Nanoscale MOSFETs

MOSFET as digital switch, Propagation delay, Dynamic and static power dissipation Moore's law, Transistor scaling, Constant field scaling theory, Constant Voltage Scaling, Generalized scaling, Short channel effects, Reverse short channel effect, Narrow width effect, Subthreshold conduction leakage, Subthreshold slope, Drain Induced Barrier Lowering, Gate Induced Drain Leakage, Design of NanoMOSFET, Halo implants, Retrograde channel profile, Shallow source/drain extensions, Twin well CMOS process flow, Gate Tunneling : Fowler Nordheim and Direct Tunneling, High k gate dielectrics, Metal gate transistor, Transport in Nanoscale MOSFET, Ballistic transport, Channel quantization.

Module-3

Designing with FINFETs

Evolution of FinFET, Principle of FinFET, Finfet Technology, FinFET Schematic, Compact Drain-Current equation, Small Signal Model of Si- Based FinFET, FinFET Fabrication Flow, Power dissipation in FinFETs, Leakage power reduction techniques, Power gating, Dual sleep, Dual stack, Sleepy stack, Basic gate design using FinFET's, combinational logic, sequential logic, Adders, Multiplier, SRAM cell design

Module-4

Designing with CNTFETs

Introduction to CNTs, CNT structure, metallic and semiconductor CNTs, energy bands in CNTs, types of CNTs: Single walled and multiwalled, physical, electrical and thermal properties of CNTs, fabrication of CNTs. CNTFETs, structure and model, small signal model, predictive technology models, N-Channel and P-Channel CNTFETs, model files of CNTFETs, basic gates using CNTFET, VI characteristics of CNTFET based

Module-5

Advances in Nanoelectronics

MOLECULAR NANOELECTRONICS: Electronic and optoelectronic properties of molecular materials, TFTs- OLEDs- OTFTs – logic switches, SPINTRONICS: Spin tunneling devices - Magnetic tunnel junctions- Tunneling spin polarization, -spin diodes - Magnetic tunnel transistor - Memory devices and sensors - ferroelectric random access memory- MRAMS

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Fundamentals of Modern VLSI Devices	Yuan Taur and Tak H. Ning	Cambridge	
2	Nanoelectronics and Nanosystems	Karl Goser, Peter Glosekotter, Jan Dienstuhl	Springer	2004
3	Designing with FINFETs and CNTFETs, MSEC	Cyril Prasanna Raj P	E-Publication	2016
4	Concepts in Spin Electronics	Sadamichi Maekawa	Oxford	2006
5	Introduction to Nanoelectronics	V. Mitin, V. Kochelap, M. Stroscio	Cambridge University Press	2008

(Group-2): 20INT252MEMS and NEMS

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction to MEMS

Historical background of Micro Electro Mechanical Systems, Feynman' s vision, Nano Technology and its Applications Multi-disciplinary aspects, Basic Technologies, Applications areas, Scaling Laws in miniaturization, scaling in geometry, electrostatics, electromagnetic, electricity and heat transfer.

Module-2

Micro and Smart Devices and Systems: Principles

Transduction Principles in MEMS Sensors: Micro sensors-thermal radiation, mechanical and bio-sensors, Actuators: Different actuation mechanisms - silicon capacitive accelerometer, piezo-resistive pressure sensor, blood analyzer, conductometric gas sensor, silicon micro-mirror arrays, piezo-electric based inkjet print head, electrostatic comb-driver, Smart phone

Module-3

Materials and Micro manufacturing

Semiconducting Materials., Silicon, Silicon dioxide, Silicon Nitride, Quartz, Poly Silicon, Polymers, Materials for wafer processing, Packaging Materials Silicon wafer processing, lithography, thin-film deposition, etching (wet and dry), wafer-bonding. Silicon micromachining: surface, bulk, LIGA process, Wafer bonding process.

Module-4

Electrical and Electronics aspects

Electrostatics, Coupled Electro mechanics, stability and Pull-in phenomenon, Practical signal conditioning Circuits for Microsystems. Characterization of pressure sensors, RF MEMS. Switches varactors, tuned filters. Micromirror array for control and switching in optical communication, Application circuits based on microcontrollers for pressure sensor, Accelerometer, Modeling using CAD Tools (Intellisuite)

Module-5

Integration and Packaging of Microelectromechanical Systems

Integration of microelectronics and micro devices at wafer and chip levels. Microelectronic packaging: wire and ball bonding, flip-chip. Microsystem packaging examples, Testing of Micro sensors, Qualification of Mems devices

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Micro and Smart Systems	G. K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat, V. K. Aatre	Wiley India	2010
2	MEMS and Microsystems Design and Manufacturing	T R Hsu	Tata McGraw Hill, 2nd Edition	2008
3	Foundations of MEMS	Chang Liu	Pearson International Edition	2006
4	Micro System Design	S. D. Senturia	Springer International Edition	2001
5				

(Group-2): 20INT253Industrial Applications of Nanotechnology	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Nanotechnology in Electrical and Electronics Industry

Advantages of nano electrical and electronic devices –Electronic circuit chips – Lasers - Micro and Nano-Electromechanical systems – Sensors, Actuators, Optical switches, Bio-MEMS – Diodes and Nano-wire Transistors - Data memory –Lighting and Displays – Filters (IR blocking) – Quantum optical devices – Batteries - Fuel cells and Photo-voltaic cells – Electric double layer capacitors – Lead-free solder – Nanoparticle coatings for electrical products

Module-2

Nanotechnology in Biomedical and Pharmaceutical Industry

Nanoparticles in bone substitutes and dentistry – Implants and Prosthesis - Reconstructive Intervention and Surgery – Nanorobotics in Surgery – Photodynamic Therapy - Nanosensors in Diagnosis– Neuro-electronic Interfaces – Protein Engineering – Drug delivery – Therapeutic applications.

Module-3

Nanotechnology in Chemical Industry

Nanocatalyts – Smart materials – Heterogenous nanostructures and composites – Nanostructures for Molecular recognition (Quantum dots, Nanorods, Nanotubes) – Molecular Encapsulation and its applications – Nanoporous zeolites – Self-assembled Nanoreactors - Organic electroluminescent displays

Module-4

Nanotechnology in Agriculture and Food Technology

Nanotechnology in Agriculture -Precision farming, Smart delivery system – Insecticides using nanotechnology – Potential of nano-fertilizers - Nanotechnology in Food industry - Packaging, Food processing - Food safety and bio-security – Contaminant detection – Smart packaging

Module-5

Nanotechnology In Textiles And Cosmetics

Nanofibre production - Electrospinning – Controlling morphologies of nanofibers – Tissue engineering application – **Polymer nanofibers** - Nylon-6 nanocomposites from polymerization - Nano-filled polypropylene fibers - **Bionics**– Swim-suits with shark-skin-effect,Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, antibacterial, hydrophilic, self-cleaning, flame retardant finishes) – **Modern textiles** (Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof, Cleaner kids clothes, Wired and Ready to Wear)

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

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Nanotechnology: A Gentle Introduction to the Next Big Idea	Mark A. Ratner and Daniel Ratner	Pearson	2003

2	Handbook of Nanotechnology	Bharat Bhushan	Barnes & Noble	2004
3	Biomedical Nanotechnology	Neelina H. Malsch	CRC Press	2005
4	Molecular Encapsulation: Organic Reactions in Constrained Systems	Udo H. Brinker, Jean-Luc Mieusset	Wiley Publishers	2010
5	Nanotechnology in agriculture and food production, Woodrow	Jennifer Kuzma and Peter VerHage	Wilson International Center	2006

(Group-3): 20INT22CHARACTERISATION TECHNIQUES	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
X-Ray based characterization Principles and applications of X-ray diffraction, powder (polycrystalline) and single crystalline XRD techniques; Debye-Scherrer equation to treat line broadening and strain induced in nanoparticles and ultra-thin films. Basics of structure refinement (Reitveld). Rotating anode and synchrotron based X-ray diffraction for probing structure.X-ray photoelectron spectroscopy – basic principle, instrumentation, X-ray absorption techniques: XANES, EXAFS.	
Module-2	
Electron microscopy techniques Introduction, Principles and applications of Electron beam, Electron beam interaction with matter. Scanning electron microscopy (SEM/FESEM), transmission electron microscopy (TEM/HRTEM), Electron-diffraction, SAED**.** Scanning Probe Microscopy: Principles and applications, Atomic Force Microscope, Scanning Tunnelling Microscope.	
Module-3	
Spectroscopic techniques UV-VIS Spectrophotometers, IR/FTIR Spectrophotometers, Principles, operation and application for band gap measurements. Raman spectroscopy principles and applications. Optical microscope: Nanoparticle size measurement by Dynamic light scattering methods zeta potential.	
Module-4	
Magnetic characterization Types of magnetic materials, Magnetic susceptibility, Curie-Weis plot for paramagnetic materials, Neel temperature, Curie temperature VSM and SQUID magnetometers – M vs H, M vs T, MH-loops.	
Module-5	
Electrical measurements Cyclic Voltameter, Impedance Measurement, IV, AC and DC electric measurements, impedance spectral information.	
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module. ■	
Textbook/Reference Books	

	Title of the book	Author Name	Publisher's Name	Publication year
1	Characterization of Nanostructure materials	XZ.L.Wang		
2	Instrumental Methods of Analysis		7th edition-Willard, Merritt, Dean, Settle	
3	Scanning Probe Microscopy: Analytical Methods (NanoScience and Technology)	Roland Wiesendanger		
4	X-Ray Diffraction Procedures: For Polycrystalline and Amorphous Materials	Harold P. Klug, Leroy E. Alexander	2nd Edition	
5	Transmission Electron Microscopy: A Textbook for Materials Science	David B. Williams and C. Barry Carter	(4-Vol Set)-	

(Group-3): 20INT323 Micro and Nano-fluidics	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction

Fundamentals of kinetic theory-molecular models, micro and macroscopic properties, binary collisions, distribution functions, Boltzmann equation and Maxwellian distribution functions-Wall slip effects and accommodation coefficients, flow and heat transfer analysis of microscale Couette flows, Pressure driven gas micro-flows with wall slip effects, heat transfer in micro-Poiseuille flows, effects of compressibility.

Pressure Driven Liquid Microflow:

Apparent slip effects, physics of near-wall microscale liquid flows, capillary flows, electro-kinetically driven liquid micro - flows and electric double layer (EDL) effects, concepts of electroosmosis, electrophoresis and dielectro-phoresis.

Module-2

Laminar flow

Hagen-Poiseullieeqn, basic fluid ideas, Special considerations of flow in small channels, mixing, microvalves&micropumps, Approaches toward combining living cells, microfluidics and 'the body' on a chip, Chemotaxis, cell motility. Case Studies in Microfluidic Devices.

Module-3

Fabrication techniques for Nanofluidic channels – Biomolecules separation using Nanochannels - Biomolecules Concentration using Nanochannels – Confinement of Biomolecules using Nanochannels.

Hydrodynamics: Particle moving in flow fields – Potential Functions in Low Renoylds Number Flow – Arrays of Obstacles and how particles Move in them: Puzzles and Paradoxes in Low Re Flow**.**

Module-4

Microfluidics and Lab-on-a-chip

Microfluidic Devices - Microchannels, Microfilters, Microvalves, Micropumps, Microneedles, Microreserviors, Micro-reaction chambers. Concepts and Advantages of Microfluidic Devices - Fluidic Transport - Stacking and Scaling – Materials for The Manufacture (Silicon, Glass, Polymers) - Fluidic Structures - Fabrication Methods - Surface Modifications - Spotting - Detection Mechanisms. Microcontact printing of Proteins-Strategies- printing types- methods and characterization- Cell nanostructure interactions-networks for neuronal cells. Applications in Automatic DNA sequencing, DNA and Protein microarrays

Module-5

BioMEMS

Introduction and Overview, Bio-signal Transduction Mechanisms: Electromagnetic Transducers Mechanical Transducers, Chemical Transducers, Optical Transducers – Sensing and Actuating mechanisms (for all types). Case Studies in Biomagnetic Sensors, Applications of optical and chemical transducers. Ultimate Limits of Fabrication and Measurement, Recent Developments in BioMEMS and BioNEMS - An alternative approach to traditional surgery, Specific targeting of tumors and other organs for drug delivery, Micro-visualization and manipulation, Implantation of microsensors, microactuators and other components of a larger implanted device or external system (synthetic organs).

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Nanofluidics	Joshua Edel	RCS publishing	2009
2	Introduction to Microfluids	PatricTabeling	Oxford U. Press, New York	2005
3	Nano Fluids; Science and Technology	K. Sarit	RCS Publishing	2007
4	Fundamentals of Microfabrication	M. Madou	CRC Press	1997
5	Micromachined Transducers	G. Kovacs	McGraw-Hill	1998

(Group-3): 20INT254Nanotechnology in Civil Engineering

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Nanomaterials as Construction Materials : History of Cementitious Systems, Current Trends in Nano-modification of Cementitious Systems, **Nano-seeding and Crystallization Control:** The Hardening of Construction Materials: Hydration in Ordinary Portland Cement, Correlation between Hydrates, Microstructure and Cohesion Properties in Cement, Gypsum Hydration, Hydration of Plaster. Experimental Techniques to Characterize the Microstructure Development. Nano-engineering of Nucleation: Design of C-S-H Nucleation and Growth. Nano-modification of Crystal Growth: Nano-modification of Gypsum Growth, From Hydration to Crystallization, From Microscopic to Macroscopic

Module-2

Nanomaterials in Cement- **The Effect of Nanomaterials on Cement Hydration and Reinforcement:** Effects of Nanomaterials and SWCNT on the Hydration of Sonicated OPC, Dispersion of SWCNT for Use in Cementitious Composites, Effects of SWCNT and Other Nanomaterials on the Hydration of C_3S and OPC, Reinforcing Behavior in SWCNT Composites

Module-3

Multifunctional and Smart Carbon Nanotube Reinforced Cement-Based Materials: Current Approaches for Dispersing CNTs in Cement-Based Materials, Reinforcement Mechanisms, Mechanical Properties of CNTs, Mechanical Properties of Nanocomposites, Electrical, Piezoresistive Thermal Conductive and Damping Properties Properties of CNTs Reinforced Cement-Based Materials, Potential Structural Applications of CNTs Reinforced Cement-Based Materials, Challenges for Development and Deployment of Multifunctional and Smart CNTs Reinforced Cement-Based Materials

Module-4

Nanomaterials-Enabled Multifunctional Concrete and Structures: Self-sensing Nano-concret and Structure, Piezoresistivity of Nano-concrete and the Modeling, Effect of Water Content on Electrical Property of CBCC and the Water-Proofing Method, Self-sensing Concrete Structures, Mechanical Properties of Nano-concret, Microstructure, Strength, Abrasion Resistance of Concrete Containing Nano-particles, Flexural Fatigue Performance of Concrete Containing Nano-particles for Pavement, Future of Multifunctional Nano-concrete

Module-5

Next-Generation Nano-based Concrete Construction Products: A Review: Incorporation of Nano-scale and Nanostructured Materials: Incorporation of Nano-SiO, during Mixing, Incorporation of Nano-TiO2, Incorporation of Nano-Al2O3, Incorporation of Nano-ZrO2, Calcium Carbonate Nano Particle Addition, Early Age Strength Increase of Belite Cement, Reinforcements of Nanotubes/Nanofibers, Nano Clay Composite. Self-healing Polymer to Control Microcracking, Self-sensing of Concrete Stress, Self Consolidating Concrete (SCC), Reactive Powder Concrete (RPC), Nanoporous Thin Film Technology to Improve Concrete Performance, Nano-engineering of Concrete Pore Solution, Controlled Release of Admixtures, Nanotechnology in Building, Nanotechnology Based Devices

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Nanotechnology in Civil Infrastructure A Paradigm Shift	Gopalakrishnan, K., Birgisson, B., Taylor, P., Attoh-Okine, N.O.	Publisher Springer International Publishing	2011
2	Nanotechnology in Construction	Sobolev, Konstantin, Shah, Surendra P	Publisher Springer International Publishing	2015
3	Nanotechnology in Eco-efficient Construction, Materials, Processes and Applications	Fernando Pacheco-Torgal Maria Vittoria Diamanti Ali Nazari Claes Goran-Granqvist Alina Pruna Serji Amirkhanian	Imprint: Woodhead Publishing	2018

4	Advanced Research on Nanotechnology for Civil Engineering Applications (Advances in Civil and Industrial Engineering)	Anwar Khitab, Waqas Anwar	Hardcover	30 June 2016
5	Smart Buildings: Advanced Materials and Nanotechnology	Casini, Marco	Woodhead Publishing	2016

(Group-3): 20INT244- Surface Engineering of Nanomaterials	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Fundamentals: Introduction to tribology, surface degradation, wear and corrosion, types of wear, adhesive, abrasive, oxidative, corrosive, erosive and fretting wear, classification of nano coatings, definition, scope and general principles, application of surface engineering towards nanomaterials

Module-2

Conventional surface engineering: Surface engineering by material removal, material addition, surface modification using liquid/molten bath, thermal and chemical treatments, gaseous medium etc.

Module-3

Advanced surface engineering practices: Surface engineering by energy beams, laser assisted microstructural and compositional modification, electron and laser beam, ion beam, plasma beam etc.

Module-4

Advanced coating practices: Cold spray, sputter deposition, ion implantation, sol-gel technique, electrolysis and electroless techniques, HVOF, PVD, PECVD, CVD, ALD etc.

Module-5

Functional coatings and Applications: Brush, Screen printing, Spray, powder, Dip-coating, ED, Fluidized Bed, Electrostatic spray gun, photovoltaics, bio-and chemical sensors, semiconductors, polymers and composites, electronic, optical and magnetic devices, modeling.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Surface Engineering & Heat Treatment	Morton, P.H	I.I.T, Brooke field	1991
2	ASM Metals Handbook: Surface Cleaning, Finishing & Coating		Ohio, Metals Park, USA.Tenth Edition	2000
3	Coating technology handbook	Satas, D. and Tracton, A.A	Mercel Dekker, New York	2001

4	Surface Engineering for Corrosion and Wear Resistance	Davis, J.R	ASM International, Materials Park, Ohio	2001
5	Corrosion Engineering	Fontana, M.G	M. C. Graw Hill, New York	2005

(Group-4): 20INT321 Modeling and Simulation in Nanotechnology	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Quantum mechanics of atoms and molecules: Hamiltonianand Wave functions-orbital approximation for multi-electronatoms-Pauli's Anti-symmetry principle, Born-Oppenheimer approximation, MO theory, LCAO approximation.Approximation methods: Necessity of approximate methods, the variation method, Perturbation method.	
Module-2	
Quantum Mechanical methods - Hartree Fock, DensityFunctional Theory, Configuration Interaction, Tight Binding,MNDO. Force Fields methods - Energy terms: valence, van der Waals, Coulomb. Functional forms, Dreiding, UFF. Chargetransfer QEq, NB Cutoffs, Splines. Minimization: steepestdescent, conjugate gradients, FP.	
Module-3	
.Molecular Dynamics simulations - NVE ensemble: Newton;s Equations, Verlet algorithms, time step. Velocity initialization(Boltzmann), Equilibration, Anneal, Quench. Analysis: fluctuations, Kubo, Free Energy Pert Theory. NVT ensemble,NPT ensemble, Quantum Hopping MD. Monte Carlo methods –Introduction, Integration, Simulation, Random Walk, Percolation, Ising Model, Markov, Metropolis, RIS, CCBB. Solvation Methods - PB, QM, MD, MC; SGB, AVGB	
Module-4	
Computational Modelling of Nanoparticles: Introduction,Benefits of Computer Science for nanotechnology, modelling atdifferent scales – electronic, atomistic, meso and continuum. Concept of computational modelling of nanostructures,computational control of matter through modelling – empiricaland Abinitio potentials, molecular dynamics simulation, monte carlo simulation, advantages and limitations of MDS and MCS. Modeling of nanoparticles - electronic transport, mechanicalproperties, optical properties. Bionanoparticles and polymer nanocomposites. Opportunities and challenges in computermodelling of nanoparticles.	
Module-5	
Modeling, design and simulation of NEMS and MEMS: Introduction, Lumped Modeling of carbon nanotubes, design and simulation of carbon nanotubes–sugar design, sugar cube design and simulation and applications. Lumped modeling of MEMS-sugar to sugarcube, Librarian, parameterization, simulation, static analysis, steady state analysis, sinusoidal analysis, transient analysis and optimization. Design and simulation of NEMS and MEMS: Sugar model, sugar cube model, carbon nanotube model in sugar, first-order analysis of thermal actuator, thermo-mechanical response of the device, electro-thermo-actuator model.	
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module. ■	

Textbook/Reference Books				
	Title of the book	Author Name	Publisher's Name	Publication year
1	Biostatistical analysis	Jerrod H.Zar	Prentice hall international Inc Press, London	1999
2	Handbook of theoretical and computational Nanotechnology	Michael Rieth and wolfram schommers		2006
3	Computational physics	R. C. Verma, K. C. Sharma & P. K. Ahluwalia		
4	Computational Nanotechnology: Modeling and Applications with MATLAB	Sarhan M. Musa		
5	Computational Finite Element Methods in Nanotechnology	Sarhan M. Musa		

(Group-4): 20INT322Nanotechnology in Diagnostics and Drug Delivery	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Principles of drug delivery systems (DDS)

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

Module-2

Nano sized Drug Carriers

Structure and Preparation- Liposomes, Cubosomes and Hexosomes, Solid Lipid Nanoparticles (SLP). Lipid based colloidal system, Liposomal Drug Carriers, Dendrimer (PAMAM), Polymer Micelle, Ceramic and Magnetic nanoparticle, Polymer drug conjugates. Nanotubes, Nanowires, Nanocage, Nanorods, Nanofibers, and Fullerenes, Carbon nanotubes biocompatibility. Smart drug delivery systems, Multifunctional Drug carriers, organic and inorganic composites. Problems with DDS, Drug loading efficiency in nanovehicles, complexity of Nanocarriers, interface between synthetic materials and biological tissues or components, safety and ethical issues, Nanotechnology for future DDS.

Module-3

Drug Discovery & Cancer therapy

Drug Discovery Using Nanocrystals, Drug Discovery Using Resonance Light Scattering (RLS) Technology. Nanosensors in Drug Discovery, Drug Delivery Applications, Nanorobots, Benefits of Nano-Drug Delivery. Use of microneedles and nanoparticles for local highly controlled drug delivery. Metal nanoparticles in drugs discovery. Nanotechnology for Cancer therapy-Nanobodies, Nanoparticles, nanoshells, Nanobombs, pebbles for brain tumor therapy, Targeting through angiogenesis and Folate Receptors Liposomal formulation in cancer therapy, application of liposomes in pharmaceutical and cosmetic applications.

Module-4

Nanomedicines

Introduction, Applications of nanobiotechnology in medicine, Role of nanotechnology in methods of treatment, Nanomedicines for Nervous system, Developing Nanomedicines, Protocols for nanodrug Administration, Nanotechnology in Diagnostics applications, materials used in Diagnostics and Therapeutic applications - Molecular Nanomechanics, Molecular devices, Nanomedicines for Skin disorders, wound healing, eye diseases, infections, Nanotubes for detection and destruction of bacteria.

Module-5

Nanoanalytics

Nanoparticles for biological labelling, Nano-Imaging Agents, Nano particles molecular labels, Immunogold-silver staining, combined fluorescent and gold probes, Protein Labeling, gold cluster labelled peptides, gold cluster conjugates of other small molecules, gold-lipids metallosomes, Larger covalent particles labels, gold targeted to His Tabs, gold cluster nanoscrystals.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Nanotechnology in Drug Delivery	Melgardt M. de Villiers, PornanongAramwit, glen s. Kwon	Springer	2009
2	NanoBiotechnology: BionInspired Devices and Materials for the Future	OdedShoweyov, Ilan Levy	Humana Press, New Jersey	2010
3	Nanobiotechnology, Concepts applications and Perspectives	C. M. Niemeyer and Chad A. Mirkin	Wiley VCH	2009
4	Bionanotechnology Global prospects II	david E Reisner	CRC Press	2012
5	Nanoparticulate Drug Delivery Systems	Deepak Thassu, Michel Deleers, Yashwant Pathak		

(Group-4): 20INT23 Advanced & Smart Materials

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Photonic Materials: Need for New Photonic Materials, composite materials for nonlinear optics, nanostructured waveguides for nonlinear optics quantum and nonlinear optics for advanced imaging applications. Nanophotonics—An Exciting Frontier in Nanotechnology. Nanophotonics at a Glance.

Module-2

Spintronic Materials: Modelling the growth of Mn on semiconductor substrates, Dilute magnetic semiconductor nanocrystals, Advances in wide bandgap materials for semiconductor spintronics

Module-3

Plasmonics: Metallic Nanoparticles and Nanorods, Metallic Nanoshells. Local Field Enhancement, Subwavelength Aperture Plasmonics, Plasmonic Wave Guiding. Applications of Metallic Nanostructures. Radiative Decay Engineering.

Module-4

Smart Materials and Systems

Thermoresponsive materials, piezoelectric materials, electrostrictive and magnetostrictive materials, Magnetic materials, superparamagntism in metallic nanoparticles, Giant and colossal magnetic materials, ferrofluids, ER and MR fluids, biomimetic materials, smart gel, shape memory alloys and polymers.

Module-5

Advanced Materials in Catalysis: Bimetallic Catalysts, Supported Bimetallic Catalysts, Graphite Intercalation Compounds as catalysts, Carbides, Nitrides, and Borides for Catalysis, Synthetic Layered Silicates and Aluminosilicates; Complex Catalysts on Inorganic Supports.

Advanced materials in Biomedical Application: Zeolite Structures as Drug Delivery Systems, Mesoporous Silica Nanoparticles and Multifunctional Magnetic Nanoparticles in Biomedical Applications, Metal-Organic Frameworks for Biological and Medical Applications

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Introduction to Solid State Physics	C. Kittel	Wiley Eastern	
2	A practical approach to X-Ray diffraction analysis	C.Suryanarayana		
3	Semiconductor Physics	P. S. Kireev	MIR Publishers	
4	Solid State Physics	A. J. Dekkar	Prentice Hall Inc	
5	Introduction to Superconductivity	M. Tinkham	McGraw-Hill, International Editions	

(Group-4): 20INT324 Nanotechnology for corrosion Science and Engineering

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction to corrosion science and engineering. Drawbacks of using hexavalent chromium coatings, nanocrystalline coatings, nano Cobalt-phosphorous, nanostructured diamond, hydroxyapatite and metalloceramics coatings, Corrosion behaviour of nc-alloys.

Module-2

Ceramic coatings: Corrosion resistance Properties of ceramic nanoparticles, hard and soft coatings, SiC, ZrO2, and A12O3 coatings. application of nano ceramic particles incorporated paints in automobile industry.

Module-3

Polymers: Introduction to nanostructured conducting polymers and their composites. Applications of polyaniline, polypyrrole, polythiophene nanocomposites in corrosion control.

Module-4

Self-assembled nanophase coating: self-assembled nanophase particle (SNAP) surface treatment. Incorporation of nanoparticles in the hybrid sol–gel systems, inhibitor nanoreservoirs for prolonged (controlled) release.

Module-5

Self-cleaning paints and biocidal coatings, super hydrophobicity, concept of contact angle, nano TiO2 based paints (photo catalysis)

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Corrosion Protection and Control Using Nanomaterials	Viswanathan S. Saji and Ronald Cook	A volume in Woodhead Publishing Series in Metals and Surface Engineering, Book	2012
2	Nano-materials for corrosion control	V. S. Sajiand Joice Thomas	REVIEW ARTICLE CURRENT SCIENCE	2007

(Group-5): 20INT331Nanobioelectronics and Applications

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Bionanoelectronics

Introduction,Photoinduced Electron transport in DNA: Toward Electronic Devices Based on DNA Architecture, Effective Models for charge Transport in DNA Nanowires, Optimizing Photoactive Proteins for Optoelectronic, DNA Based Nanoelectronics, Electrical Manipulation of DNA on Metal Surfaces.

Module-2

Microfluidics Meets Nano:

Introduction, Overview, Definition and History, Advantages of Microfluidic Devices, Concepts for Microfluidic Devices, Fluid Transport, Stacking and Sealing, Methods, Materials for the Manufacture of Microfluidic Components, Silicon, Glass, Polymers, Fluidic Structures, Fabrication Methods, Surface Modifications, Spotting, Detection Mechanisms.

Module-3

Nanoparticle-Biomaterial hybrid systems for Bioelectronic Devices and Circuitry

Introduction, Biomaterial- Nanoparticles Systems for Bio-electtronic and Biosensing Applications, Bioelectronic systems based on nanoparticle-Enzyme Hybrids, Bioelectronic Systems for sensing of biorecognition events on Nanoparticles, Biomaterial based Nanocircuitry, Protein based Nanocircuitry, DNA as Functional Template for Nanocircuitry

Module-4

DNA based Nanostructures

Overview, Introduction, Oligonucleotide-Enzyme Conjugates, DNA Conjugates of binding proteins, Noncovalent DNA Streptavidin Conjugates, Multifunctional Protein Assemblies, DNA Protein Conjugates in Microarray Technologies, Methods,Conjugation of Nucleic Acids and Protein, Immuno PCR, Supramolecular Assembly, DNA directed Immobilization, DNA templated Electronics, Sequence Specific Molecular Lithography.

Module-5

Nanoparticle Molecular labels

Introduction, Immunogold Silver staining, Combined Fluroscent and Gold probes, Methodology, Choice of Gold and AMG Type , Iodization, Sensitivity, Applications for the microscopical detection of Nucleic acids, guidelines and laboratary protocols, Gold derivatives of other biomolecules, protein labeling, gold Cluster of conjugates of other small molecules, gold lipids: metallasomes, Larger Covalent particle labels, Gold Targeted to His Tags, Enzymes Metallography, Gold Cluster Nanocrystals, Gold Cluster Oligonucleotide Conjugate: Nanotechnology applications, DNA Nanowires, 3-D Nanostructured Mineralized Biomaterials, Gold Quenched molecular beacons, Other Metal Cluster Labels, Platinum and Palladium, Tungstates, Iridium.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Nanobiotechnology	C Niemeyer, Chad Mirkin	WILEY-VCH , ISBN 3-527-30658-7	
2	Nanobiotechnology	OdedShoseyov, Ilan Levy	Humana Press Inc., ISBN 978-61737-830-0	

(Group-5): 20INT332 Micro-Nano Packaging	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Fundamentals of the Design and Packaging Process - Systems Engineering, Quality Concepts, Engineering Documentation, Design for Manufacturability, ISO9000, Bids and Specifications, Reference and Standards Organizations. Introduction to Micro and nano systems packaging, role of packaging as IC and device packaging, fundamentals of electrical package design, Single Chip, Multi-chip, IC assembly, and Wafer Level Packaging

Module-2

Surface Mount Technology - Introduction, Surface Mount Device Definitions, Substrate Design Guidelines, Thermal Design Considerations, Adhesives, Solder Joint Formation, Parts, Reflow Soldering, Cleaning and Prototype Systems. Direct Chip Attach - Overview of Die Assemblies, Known Good Die, Chip on Board, Flip Chips, and Chip-Scale Packages

Module-3

Circuit Boards- Overview, Basic Circuit Board Design, Prototypes, DFM and DFT Issues, Board Materials, Circuit Design and Board Layout, Simulation, Standards. Hybrid Assemblies: Introduction, Ceramic Substrates, Thick Film, Thin Film, Chip Resistors and Multilayer Ceramic Capacitors, Component and Assembly Packages, Buried Passive Circuit Elements, Bare Die Assembly, Multichip Module Technology

Module-4

Interconnects - General Considerations, Wires for Interconnection, Single-Point Interconnects, Connectors, Board Interconnects, Component Sockets, Fiber-Optic Interconnects and Connections, Coaxial Cable and Interconnects, Microwave Guides and Couplers. **Thermal Management:** Fundamentals ofHeat, Engineering Data, Heat Transfer, Heat Removal/Cooling. **Testing**: Testing Philosophies, Test Strategies, Sources of Faults, Automatic Test Methods, Test Fixtures, Environmental Stress Screening, Test Software, and Testing Software Programs.

Module-5

Inspection - General Inspection Criteria, Solder Paste Deposition Volume, Solder Joint Inspection Criteria, Visual Inspection, Automated Optical Inspection, Laser Inspection, X-Ray Inspection. Package/Enclosure: Introduction, Ergonomic Considerations, User Interfaces, Environmental Issues, Maintenance, Safety. **Electronics Package Reliability and Failure Analysis**: Reliability, Micro-mechanisms of Failure in Electronic, Packaging Materials, Package Components, Failure Analyses of Electronic Packages, Thermal Management, Product Safety and Third-Party Certification.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	The electronic packaging handbook	Glenn R. Blackwell	CRC Press	2000
2	Fundamentals of microsystem packaging	Rao R. Tummala	McGraw-Hill	2004
3	Micro- and Opto-Electronic Materials and Structures: Physics, Mechanics, Design, Reliability, Packaging	E. Suhir, Y.C. Lee, and C.P. Wong	Springer Science	2007
4	Nanopackaging: Nanotechnologies and Electronics Packaging	James E. Morris	Springer Science	2008
5				

(Group-5): 20INT333Advances in Nanodevices	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Nanoelectronic Devices

Nano-CMOS modelling, Nano-CMOS Predictive Technology Model, Mobility and Dopant Number Fluctuation Model, Random interface traps, Nano-CMOS Technology, Bottom-Up approach for CMOS scaling, Low power adders.

Module-2

Nano Capacitors and Terahertz systems

Package-compatible high density nanoscale capacitors, Carbon nanostructures for display and energy, Nano antennas for energy conversion, Ballistic transistor logic for circuit applications.

Module-3

Memristors, Resistive switches and memory

Nanodevices: functions and Lienard equation, Sensing and writing operations of nanocross bar memory arrays, Complementary resistive switches, Memory cell using memristor, Thermally actuated nanoelectromechanical memory

Module-4

CNT and Nanowire

Fabrication of single walled CNT, CNT for TFT, Yield improvement techniques for CNTFET, GaAs nanowires on Si Substrates, Tin Oxide Nanowires for Gas sensing, Cu Silicide Nanowires for Li-Ion Batteries, Zinc Oxide Nanowires for bio sensing, ZnO thin film transistors.

Module-5

Microfluidics and Lab-on-a-chip: Microfluidic Devices - Microchannels, Microfilters, Microvalves, Micropumps, Microneedles, Microreserviors, Micro-reaction chambers. Concepts and Advantages of Microfluidic Devices - Fluidic Transport - Stacking and Scaling – Materials for The Manufacture (Silicon, Glass, Polymers) - Fluidic Structures -Fabrication Methods - Surface Modifications - Spotting - Detection Mechanisms. Micro contact printing of Proteins-Strategies- printing types- methods and characterization- Cell nanostructure interactions-networks for neuronal cells. Applications in Automatic DNA sequencing, DNA and Protein microarrays.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Nanoelectronic Device Applications Handbook	James E. Morris, Krzysztof Iniewski	CRC Press, Taylog& Francis Group	2017
2	Biosensors Based on Nanomaterials and Nanodevices	Jun Li, Nianqiang Wu	CRC Press, Taylog& Francis Group	2014
3	Nanodevices for the Life Sciences	Challa S. S. R. Kumar	Wiley-VCH Verlag GmbH	2006
4				
5				

(Group-5): 20INT334 Nanotechnolgy in Food and Agriculture	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction: Rhizosphere, Emulsions, Surfactants-Biodegradable and non biodegradable, Pesticides, Insecticides, Herbicides, Weedicides, Biomagnification, Micro and Macro nutrients required by plants. Various types of nanomaterial utilized in agriculture, Soil health-Different Indicators (Assays) for determining soil health.

Module-2

Nanoparticles in agricultural and food diagnostics: Enzyme Biosensors and Diagnostics - DNA-Based Biosensors and Diagnostics Radiofrequency IdentificationIntegrated Nanosensor Networks: Detection and Response- Lateral Flow (Immuno)assay - Nucleic Acid Lateral Flow (Immuno)assay - Flow-Through (Immuno)assays - Antibody Microarrays Surface Plasmon Resonance Spectroscopy

Module-3

Nanotechnology in food production: Food and New Ways of Food Production - Efficient Fractionation of Crops Efficient Product Structuring -Optimizing Nutritional Values - Applications of Nanotechnology in Foods : Sensing, Packaging, Encapsulation, Engineering Food Ingredients to Improve Bioavailability - Nanocrystalline Food Ingredients - NanoEmulsions - Nano-Engineered Protein Fibrils as Ingredient Building Blocks Preparation of Food Matrices - Concerns about Using Nanotechnology in food production.

Module-4

Nanotechnology in food packaging: Crop improvement - Reasons to Package Food Products - Physical Properties of Packaging Materials - Strength - Barrier Properties Light Absorption – Structuring of Interior Surfaces - Antimicrobial Functionality - Visual Indicators – Quality Assessment - Food Safety Indication - Product Properties - Information andCommunication Technology - Sensors - Radiofrequency Identification Technology Risks - Consumer and Societal Acceptance.

Module-5

Technology Issues: Life Cycle of Nanotechnology FoodProducts, Molecules in Foods Involved in Triggering Allergies,Food Structure, Processing, and Food Allergy, Impact of Nanoscale Structures on Allergenic Potential of Foods,Innovations in Food and Agriculture Nanotechnology.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Nanotechnology in the Agri-Food Sector	Lynn J. Frewer,Willem Norde, Arnout Fischer, Frans Kampers	John Wiley and Sons	2010
2	Applied Nanotechnology in Agriculture	S.Choudhary	Arise Publication	2011

3	Nanoparticle Assemblies and Superstructures	Nicholas A. Kotov	CRC	2006
4	Nanotechnology in agriculture and food production	Jennifer Kuzma and Peter VerHage Woodrow	Wilson International	2006
5	Bionanotechnology	David S Goodsell, John Wiley & Sons		2004

(Group-6): 20INT15 Carbon Based Nanostructures	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Carbon Nanotubes (CNT): History, types of CNTs, synthesis methods, CVD method, Laser ablation and electric arc processes, growth mechanisms, purification and characterization methods, mechanical reinforcements, solid disordered carbon nanostructures	
Module-2	
Graphene: Background, structure, exfoliation or synthesis methods- physical methods-micromechanical (scotch tape method), CVD, electric arc process. Chemical approaches-Hammers method, oxidation and reduction of graphite, solvothermal, supercritical fluid, solvent sonication method, chemically modified graphene, electrochemical synthesis and other methods	
Module-3	
Fullerenes and derivatives: Fullerenes and types, diamond like carbon, nanodiamond, clusters, metal carbide derived carbon nanostructures, synthesis and applications. **Nanostructures**: Graphite, Whiskers, Cones, and Polyhedral crystals, structure, properties and applications	
Module-4	
Functionalization of carbon nanostructures: (CNT, Graphene and fullerenes)- reactivity, covalent functionalization-oxidative purification, defect functionalization, transformation and modification of carboxylic functionalization like amidation, thiolation, halogenations, hydrogenation, addition of radicals, sidewall functionalization through electorphilic addition, nano covalent exohedralfunctionalization, endohedro functionalization.	
Module-5	
Properties of Carbon nanostructure: Electronic, Vibrational, Mechanical Properties of CNTs, optical properties & Raman spectroscopy of CNTs. **Application of Carbon nanostructure** in Lithium ion battery, fuel cells, hydrogen storage, sensor applications, applications to nanoelectronics, nanocomposites, nanowires in drug delivery, polymer reinforcement and as filler materials	
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module. ■	
Textbook/Reference Books	

	Title of the book	Author Name	Publisher's Name	Publication year
1	Carbon Nanotubes: properties and applications	Mchael J. O'Connell	Taylor & Franc	2006
2	Nanotubes and Nanowires	CNR Rao and A Govindaraj	RSC publishing	
3	Handbook of Carbon	YuryGagotsi	Taylor & Francis	2006
4	Physical properties of carbon nanotube	R. Satio		
5	Applied physics of Carbon nanotubes: fundamentals of theory, optics and transport devices	S.Subramoney and S.V.Rotkins		

(Group-6): 20INT31 Nanomaterials and Energy Systems	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Renewable energy Technology: Energy challenges, nanomaterials and nanostructures in energy harvesting, developments and implementation of nanotechnology based renewable energy technologies, solar cell structures: quantum well and quantum dot solar cells, photo-thermal cells for solar energy harvesting, thin film solar cells, CIGS solar cells, Dye sensitized solar cells. Organic PV cells, Concentrated solar power (CSP): Reflective materials, absorptive coatings, thermal storage.	
Module-2	
Energy storage: Introduction, Battery types, Li-ion Battery, Battery components materials, cathodes, anodes, effect of nanosize on energy storage and electrode materials performance. Next generation batteries, Li-Air, Li-S, Na ion battery, Mg ion battery. LIB for automobiles application, EV's, HEV, PHEV and power grid.	
Module-3	
Super capacitors: Introduction, Electrochemical energy storage, Electrochemical capacitors, Electrochemical double layer capacitor, electrode materials supercapacitors, Hybrid Nanostructures for supercapacitors- metal oxides, conducting polymers, Electrolytes for super capacitors, types of electrolytes.	
Module-4	
Hydrogen Generation and storage technology: Hydrogen production methods, Electrochemical and photocatalytic H2 Generation using Nanomaterials, purification, hydrogen storage methods and materials: metal hydrides and metal organic framework materials, volumetric and gravimetric storage capacities, hydriding and dehydriding kinetics, high enthalphyformations and thermal management during hydriding reaction, multiple catalytic- degradation of sorption properties, automotive applications. Catalyst of hydrogen production, steam reforming & Water splitting. Nanoporous membranes for hydrogen separation.	
Module-5	

Fuel cell technology: Fuel cell principles, types of fuel cells (Alkaline Electrolytie, phosphoric acid, Molten carbonate, solid oxide and direct methanol and proton exchange fuel cells), Principle and operation of proton exchange membrane (PEM) fuel cell, materials and fabrication methods for fuel cell technology, micro fuel cell power sources-biofuels.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Handbook of Batteries and Fuel Cells	D. Linden	Mcgraw-Hill, New York	1984
2	Advances in Lithium- Ion Batteries	W. A. van Schalkwijk and B. Scrosati	Kluwer Academic Publishers, Newyork	2002
3	Handbook of Batteries	Linden , D. and Reddy , T.B	3rd edn , McGraw - Hill , New York	
4	Battery Reference Book	Crompton, T.R.	3rd edn , Newnes , Oxford	
5	High Energy Density Lithium Batteries	K. E. Aifantis and S. A. Hackney and R. Vasant Kumar	Wiley-VCH Verlag	2009

(Group-6): 20INT21 Design and Fabrication Techniques

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

The Science of Miniaturization

Miniaturization of Electrical and Electronic Devices, Moore's law and technology road map, Quantum Mechanical Aspects, Simulation of the Properties of Molecular Clusters, Formation of the Energy Gap, Confinement Effects, Discreteness of Energy Levels, Tunnelling Currents.

Module-2

Nanofabrication by Photons

Principles of Optical Projection Lithography, Process of Optical Lithography. Photoresists Characteristics. Optical Lithography at Shorter Wavelengths-Deep UV, Extreme UV and X-ray Lithography. Optical Lithography at High Numerical aperture, Near-Field Optical Lithography.

Module-3

Nanofabrication by Ion Beam

Introduction, Liquid Metal Ion Sources, Focused Ion Beam Systems, Ion Scattering in Solid Materials , FIB Direct Nanofabrication , Ion Sputtering, Ion Beam Assisted Deposition, Applications, Focused Ion Beam Lithography, Ion Projection Lithography.

Module-4

Nanofabrication by Scanning Probes

Introduction, Principles of Scanning Probe Microscopes, Exposure of Resists- Exposure of Resist by STM, Exposure of Resist by NSOM, Additive Nanofabrication, Field Induced Deposition, Dip-Pen Nanolithography, Subtractive Nanofabrication-Electrochemical Etching, Field Induced Decomposition, Thermomechanical Indentation, Mechanical Scratching, High Throughput Scanning Probe Lithography.

Module-5

Fabrication of micro/nano devices

Microfluidic Devices - Microchannels, Microfilters, Micro- valves, Micropumps, Microneedles, Microreserviors, Micro-reaction chambers. Lithium Ion Battery and Super capacitors device fabrication, Operating and structure of Solar cells-CIGS solar cells, Dye-Sensitized solar cells, and Perovskite solar cell. MEMS and NEMS based devices`

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year
1	Nanostructures & Nanomaterials Synthesis, Properties	Guozhong Cao	World Scientific Publishing Private, Ltd., Singapore	2004
2	Nanotechnology and Nanoelectronics – Materials, Devices, Measurement Techniques	W.R.Fahrner	SpringerVerlag Berlin, Germany	2006
3	Nanostructure control of materials	R. H. J. Hannink and A. J. Hill	Woodhead Publishing Limited and CRC Press LLC, Cambridge, England	2006
4	Nanofabrication, Principles, Capabilities and Limits	Zheng Cui	Springer Science + business media, New York	2008
5	Handbook of Nanostructured Materials and Nanotechnology	Hari Singh Nalwa	(Vol. 3)-Electrical Properties, Academic Press, San Diego, USA	2000

(Group-6): 20INT242Nanocomposites and its applications	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction to nanocomposites

Definition of composite material, Classification based on matrix and topology, Constituents of composites, Interfaces and Interphases, Distribution of constituents, Nano-composites. Advantage of composite materials, mechanical properties, Thermal, electrical and electronic and optical properties. Super hard nanocomposites-designing and mechanical properties - stress-strain relationship, toughness, strength, and plasticity.

Module-2

Ceramic metal nanocompsites

Ceramic based nanoporous composites, metal matrix nanocomposites, natural nano-bioccomposites, bio-mimetic nanocompostes and biologically inspired nanocomposites, nanocompsites for hard coatings, DLC coatings, thin film naocomposites, modelling of nanocomposites, synthesis of various nanocomposites materials, sputtering, mechanical

Module-3

Polymer nanocomposites

Introduction to polymer composites, Processing of nanoparticles, binding mechanisms in nanoparticles, dispersion of nanoparticles, and stabilization of nanoparticles. Processing and fabrication of polymer nanocomposites, Melt blending, solvent casting, In-situ polymerization, solution polymerization, template synthesis, high shear mixing. Homogeneous/heterogeneous nucleation, plasma promoted nucleation. Polymer nanocomposites with structural, gas barrier and flame retardant properties, carbon fibre reinforced polymer composites, elastomer and thermoplastic elastomer nanocomposites for propulsion systems, water borne fire-retardant nanocomposites, hybrid composites for cosmetics,protective and decorative coatings.

Module-4

Natural nanocomposite systems

Spider silk, bones, shells; organic–inorganic nanocomposite formation through self-assembly. Biomimetic synthesis of nanocomposite material; use of synthetic nanocomposites for bone teeth replacement. Bioactive nanocomposites in bone grafting and tissue engineering, inorganic/polymer nanocomposites for dental restoration and bone replacement applications.

Module-5

Bio ceramics for implant coating

Calcium phosphates-hydroxyapatites Ti6Al4V and other biomedical alloys, implant tissue interfacing-metal organic CVD-use of tricalcium phosphate-biomimetic and solution based processing- osteoporosis- osteo plastic, regeneration of bones by using bio compatible ceramics, bio interactive hydro gels- PEG coating and surface modifications, PEG hydrogels patterned on surfaces- PEG based hydrogels.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	Author Name	Publisher's Name	Publication year

1	Nanocomposite science and technology	M.Ajayan, L.S. Schadler and P.V. Braun	Wiley-VCH GmbH Co.	2003
2	Encyclopedia of Nanotechnology	H.S.Nalwa	American Scientific Publishers	2003
3	Metalopolymer nanocomposites	Ed A.D. Pomogailo and V.N.Kestelman,	Springer-Verlag	2005
4	Composite materials	K.K. Chawala	2nd Edition Springer-Verlag, New York	1987
5	Biomedical nanostructures	Kenneth E.Gonsalves, Craig R. Halberstadt, Cato T. Laurencin, Lakshmi S. Nair	John-Wiley & Sons	2008