

Core Courses for Semester – III

MSNT301-CR	Nanomaterials: Properties & Applications
4 Credits	

Unit-I

Fundamental types of electronic nanomaterials. Microelectronics. Electrical conductivity in nanotubes, nanorods and nanocomposites. Photoconductivity of nanorods. Electronic transport in nanostructures, Quantum waveguides, single electron transfer devices (SETs), Electron spin transistor – resonant tunnel devices - quantum interference transistors (QUITs), Electronic properties of Carbon Nanotubes.

Unit-II

Dia, para and ferromagnetic materials, Origin of magnetism – various theories, temperature dependence, domain structure ferromagnetic domains, antiferromagnetism, magnetic hysteresis and coercive force. Magnetization and nanostructures: Superparamagnetic particles-susceptibility and related phenomena in superparamagnets- Physical properties of magnetic nanostructures-exchange coupled magnetic nanomaterials-spin-polarized tunnelling- magnetoresistivity, Data storage applications of magnetic nanoparticles, spintronic devices, Magnetic properties of Carbon Nanotubes.

Unit-III

Interaction of light with matter. The nano perspective. The surface plasmon – SPR and scattering-colour generation from nanoparticles and nanostructures - applications of nanoplasmonics. Quantum dots-Optical properties related to quantum confinement. Special luminescent nanocomposites. Electroluminescence-photochromic and electrochromic nanomaterials. Confinement and propagation of photons. Internal reflection and evanescent waves, Nanophotonic and Plasmonic Applications: nanolasers, nano-antennas, photonic crystals.

Unit-IV

Nanomechanics - Introduction- three atom chain- lattice mechanics- linear elasticity relations – molecular dynamics. Structure and mechanical properties of carbon nanotubes and its Composites- nanomechanical measurement techniques- AFM-Nanoindentation. Nanothermodynamics: Thermodynamics the nano perspective – Background- application of classical thermodynamics to nanomaterials- small system thermodynamics. Modern nanothermodynamics - Nonextensivity and nonintensity – nanothermodynamics of a single molecule.

Books Recommended

- ♣ *The Physics & Chemistry of Nanosolids* by Frank J. Owens and Charles P. Poole Jr., John Wiley & Sons, 2008.
- ♣ *Optical Properties of Nanostructures* by Ying Fu, Min Qiu.
- ♣ *Handbook of Nanophysics: Principles and Methods* by Klaus D. Sattler.
- ♣ *Principles of Nanomagnetism (Nanoscience and Technology)* by A. P. Guimarães.
- ♣ *Solid State Chemistry and its Applications* by AR West.

♣ *Foundations of Nanomechanics: From Solid-State Theory to Device Applications* by Cleland, Andrew N.

MSNT302-CR	NANOMEDICINE-I: Applications in Therapeutics & Diagnostics
4 Credits	

Unit-I

Introduction to Nanomedicine: challenges and opportunities, Applications of nanoscience in biological systems- drug targeting & drug delivery, Various nanoscale materials in drug delivery: Biodegradable nanoparticles and their fate in -vivo: PLGA, PLA, chitosan and protein nanoparticles. Biological barriers encountered by biodegradable nanoparticles, Viral Vectors, Nonviral Delivery Vectors: Liposomes, Polymers, and Dendrimers.

Unit-II

Specific Location - Based Strategies for Nanoparticulate Drug Delivery to the Reticuloendothelial System and to Associated Disorders, Delivery of Nanoparticles to the Cardiovascular System; Nanocarriers for the Vascular Delivery of Drugs to the Lungs; Blood-Brain Barrier (BBB)- Nanoparticulate Carriers for Drug Delivery across barrier to the Brain etc.. Nanoparticles for Targeting Lymphatics, Polymeric Nanoparticles for Delivery in the Gastro-Intestinal Tract, Nanoparticles and Microparticles as Vaccines Adjuvants.

Unit-III

Cancer Nanotherapeutics: Physicochemical approaches for targeting drug delivery- Magnetic thermal and pH assisted drug delivery. Affinity based (Synaptic) delivery of nanocomposites, Receptor based delivery, Peptides as targeting agents, RGD, iRGD and CendR sequences, vascular Zip codes, Pathways for cellular uptake of nanoparticles, monitoring endocytic pathways, factors affecting cellular response of nanoparticles, EPR effect for cancer therapeutics, Sustained release cancer nanotherapeutics.

Unit-IV

Nanodiagnostics: Nanodiagnostics, Nanoarrays for diagnostics, detection of single DNA, self, assembled protein nanoarrays, protein nanobiochip, nanoparticles for molecular diagnostics, DNA nanomachines, Nanosensors as diagnostic tool in bio-medical applications, DNA nanosensors, Nanowire biosensor- as diagnostic tool in bio-medical applications,

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Books Recommended

- ♣ *Nanoparticles as Drug carriers*, Vladimir P Torchilin, Imperial College Press, USA, 2006.
- ♣ *Nanomedicine*, Parag Diwan and Ashish Bharadwaj, pentagon press, India, 2006.
- ♣ *Targeted Drug Delivery: Concepts and Design*, Padma V. Devarajan & Sanyog Jain, Springer.
- ♣ *Nanoscience: Nanobiotechnology and Nanobiology*, P. Boisseau, P. Houdy and M. Lahmani, Springer, 2007.
- ♣ *Nanobiotechnology*, C.M.Niemeyer, C.A. Mirkin, Wiley VCH, 2004.

- ♣ *Nanobiotechnology: Concepts, Applications and Perspectives*, Christof M.Niemeyer, Chad A.Mirkin, Wiley-VCH, Weinheim, 2004.
- ♣ *Nanomedicine, Volume 509: Methods in Enzymology*, Academic Press,
- ♣ *Bionanotechnology: Lessons from Nature*, David S. Goodsell, Wiley-Liss, 2004.
- ♣ *Nano Biotechnology Protocols*, Sandra J. Rosenthal, David W. Wright, Humana Press, New Jersey, 2005.
- ♣ *Protein Nanotechnology, Protocols, Instrumentation and Applications*, Tuan VoDinh, Humana Press, New Jersey, 2005.

MSNT303-CR	Nanoelectronics: Nanodevices and Nanosensors
4 Credits	

Unit-I

Introduction- Nanoelectronics: Quantum confinement and Bohr exciton radius – Quantum size effect – Quantum nanostructures, Quantum well, wire and dot. Semiconductor Nanodevices: Single-Electron Devices, Nano scale MOSFET – Resonant Tunnelling Transistor - Single-Electron Transistors; Single-Electron Dynamics; Nanorobotics and Nanomanipulation; Molecular Nanowires, Organic Field Effect Transistors (FET)- Carbon nanotube (CNT) and Graphene FTE, silicon nanowire (SiNW) FET.

Unit-II

Fundamentals of sensors, biosensor, micro fluids, MEMS and NEMS. Packaging and characterization of sensors. Nanobiosensor- CNT biosensor, Nanowire Biosensors, Sensors for aerospace and Defense: Accelerometer, Pressure Sensor, Night Vision System, Nano tweezers, nano-cutting tools, Integration of sensor with actuators and electronic circuitry, Civil engineering applications: metrology, bridges etc

Unit-III

Synthesis and applications of semiconductor nanoparticles – Optical luminescence and fluorescence from direct band gap semiconductor nanoparticles, surface-trap passivation in core-shell nanoparticles, carrier injection, pn junction, LED and solar cells, electroluminescence, Mn-Zn-Se phosphors, light emission from indirect semiconductors, light emission from Si nanodots. Recent advances in solar cell technology, Perovskite and dye sensitized solar cells.

Unit-IV

Hetero-structure semiconductor lasers–Quantum well semiconductor lasers–Vertical cavity surface emitting lasers (VCSELs) –Strained quantum well lasers, Quantum dot lasers– Quantum well and super lattice photo detectors–Quantum well modulators–Organic LED.

Books Recommended

- ♣ *J. M. Martínez-Duart, R.J. Martín-Palma and F. Agulló-Rueda, Nanotechnology for Microelectronics and Optoelectronics*, Elsevier B.V.
- ♣ *Nanomaterials for Biosensors*, Cs. Kumar, Wiley – VCH, 2007.
- ♣ *Smart Biosensor Technology*, G.K. Knoff, A.S. Bassi, CRC Press, 2006.
- ♣ *SE Lyshevski, “MEMS and NEMS: Systems, Devices, and Structures”* 2002.

- ♣ *Handbook of Semiconductor Nanostructures and Nanodevices, Vol 1-5-A. A. Balandin K. L. Wang, American Scientific Publishers, 2005*
- ♣ *J. M. Martínez-Duart, R.J. Martín-Palma and F. Agulló-Rueda, Nanotechnology for Microelectronics and Optoelectronics, Elsevier B.V.*
- ♣ *Solar photovoltaics, Fundamentals, Technologies and Applications by Chetan Singh Solanki, PHI Learning Private Limited, Delhi-110092.*

MSNT304-CR	Seminar & Research Methodology
2 Credits	

Unit-I

Seminar: Each candidate shall present a seminar on recent topics in frontier areas of research in the department seminar. Performance of the candidates in the seminar shall be evaluated jointly by all faculty members.

Unit-II

Research methodology – definition, statistical tools for analysis of data, Types of research, exploratory research, conclusive research, modelling research, algorithmic research, Research process- steps. Data collection methods- Primary data – observation method, personal interview, telephonic interview, mail survey, questionnaire design. Secondary data - internal sources of data, external sources of data. Bioinformatics based tools for research.

Books Recommended

- ♣ *Kothari, C. R., Research Methodology –Methods and techniques, New Age Publications, New Delhi, 2009.*
- ♣ *Panneerselvam, R., Research Methodology, Prentice-Hall of India, New Delhi, 2004*

Discipline Centric Courses – Semester -III (Compulsory)

MSNT305-DCE	Nanotechnology Laboratory Course-II
4 Credits	

The Experiments for Nanotechnology Laboratory Courses for Semesters II will be conducted as per the availability of infrastructure and instrumentation. Following the proposed experiments for

Nanotechnology Laboratory Course-II (Practical's)

1. Chemical synthesis of metal acetylacetonates to be used as precursors for nanomaterial synthesis.
2. Microwave assisted synthesis of metal-oxide nanoparticles and their characterization
3. Thin-film deposition of metal oxides on different substrates using microwave assisted deposition technique.
4. Electrospinning route for synthesis of nanofibers and their composites.
5. Sonochemical synthesis of nanomaterials.

6. Silicon wafer cleaning and growth of oxide layer over it, and measurement of contact angle of water (and maybe other liquids).
7. Fabrication of a simple version of perovskite solar cell.
8. Deposition of Titania thin films by Sol-Gel method and studying the effects of post deposition annealing on the crystalline properties.
9. Formation of thin films using PVA and ZnO nanoparticles for packaging.
10. Isolation of Genomic DNA isolation from Human samples and medicinal plant.
11. Isolation of Plant genomic DNA from a Separation of peripheral mononuclear cells from the blood.
12. Cultivation of bacteria/ fungi.
13. Drug administration methods and animal models of Drug discovery.
14. Synthesis of Nanomaterial using biological methods (bacteria/fungi/plants).
15. Synthesis of polymeric biodegradable nanoparticles.
16. Encapsulation of drug in nanoparticles

MSNT206-DCE	Nanomedicine - II: biomedicine, Current Status & Challenges
2 Credits	

Unit-I

Nanotechnology and Stem cells: Current and Future Perspectives of Regenerative Medicine, Biologic and Molecular Aspects of Regenerative Medicine- Embryonic Stem Cell Types, Fetal Stem Cells, Adult Stem Cells. Stem cell-based therapies in disease, Nanotechnology and Stem cells- Nano based recent advances in stem cell therapies and Regenerative Medicine. Biomaterials & Bioprinting in Regenerative Medicine.

Unit-II

Recent advancement in Nano-bio interface: Interactions of cells with nanomaterials in-vivo and in vitro: Dependence of interaction on physiochemical properties of nanomaterials, biocompatibility, surface functionalization as a means to enhance biocompatibility. Approved drug therapies based on Nanotechnology, Current Nano based therapeutics in clinical trials, *In vivo* Nano-toxicity issues. Manufacturing and quality assurance of nanomedicine products, the absolute requirement for GMP, Current regulatory approach to nanomedicines.

Books Recommended

- R. Lanza. Gearhart et al (Eds), *Essentials of Stem Cell Biology*. 2009, Elsevier Academic press.
- *Stem cells: a revolution in therapeutics-Recent advances in stem cell biology and the applications in regenerative medicine and cancer therapies*, M Mimeault, R Hauke and S K Batra, *Clinical Pharmacology & Therapeutics*.
- Ferreira, L. et al. *New opportunities:2008 The use of nanotechnologies to manipulate and track stem Cells*.
- *Nanoscience: Nanobiotechnology and Nanobiology*, P. Boisseau, P. Houdy and M. Lahmani, Springer, 2007.
- *Nanobiotechnology*, C.M.Niemeyer, C.A. Mirkin, Wiley VCH, 2004.
- *Nanobiotechnology: Concepts, Applications and Perspectives*, Christof M.Niemeyer,

Chad A. Mirkin, Wiley-VCH, Weinheim, 2004.

- *Bionanotechnology : Lessons from Nature*, David S. Goodsell, Wiley-Liss, 2004.
- *Nano Biotechnology Protocols*, Sandra J. Rosenthal, David W. Wright, Humana Press, New Jersey, 2005.
- *Protein Nanotechnology, Protocols, Instrumentation and Applications*, Tuan VoDinh, Humana Press, New Jersey, 2005.
- Challa S. S. R. Kumar, *Nanomaterials - Toxicity, Health and Environmental Issues*, Wiley-VCH publisher (2006).
- D. Drobne, *Nanotoxicology for safe and Sustainable Nanotechnology*, Dominant publisher (2007).

MSNT305-DCE	Environmental Nanotechnology
2 Credits	

Unit 1

Sensors based on carbon nanomaterials for water monitoring, Electrochemical nanosensors for detection of pesticides, Nucleic acid based colorimetric and fluorescent sensors for trace contaminants in water. Nanostructured membranes for water purification, Nanostructured TiO₂, Film and membrane-based photocatalysts for water treatment, Dendrimer-enhanced filtration. Nanomaterials-assisted plasma technology for water remediation, Removal of fluorides from potable water using nanomaterials, Iron oxide nanomaterials for Photo-Fenton conversion of water pollutants.

Unit 2

Nanotechnology in Agriculture, Precision farming, Smart delivery system, Insecticides using nanotechnology, Potential of nanofertilizers. Nano pesticide application and Evaluation, Application of Nano technology in pest management
Nanotechnology in Food industry, Smart packaging, and Fabrication process – Usage of nano material in food packaging - solid and liquid food – overall migration - Safety issues of nano food systems.

Books Recommended

- ♣ *Application of Nanotechnology in Water Research*; edited by Ajay Kumar Mishra
- ♣ *Nanotechnology Applications for Clean Water*, edited by A. Street, R. Sustich, Jeremiah Duncan, N. Savage
- ♣ *Sensors and Transducers: Characteristics, Applications, Instrumentation, Interfacing*; M.J. Usher, D.A. Keating
- ♣ W.N. Chang, *Nanofibres fabrication, performance and applications*, Nova Science Publishers Inc, (2009).
- ♣ Nancy A. Monteiro-Riviere, C. Lang Tran, *Nanotoxicology: Characterization, Dosing and Health Effects*, Informa healthcare (2007).
- ♣ Lynn J. Frewer, Willehm Norde, R. H. Fischer and W. H. Kampers, *Nanotechnology in the Agri-food sector*, Wiley-VCH Verlag, (2011).
- ♣ Jennifer Kuzma and Peter VerHage, *Nanotechnology in agriculture and food production*, Woodrow Wilson International Center, (2006)