DEPARTMENT OF NANOTECHNOLOGY
UNIVERSITY OF KASHMIR
SRINAGAR-190006

MASTERS (M.Sc.) CURRICULUM

in

NANOTECHNOLOGY PROGRAM

- 2018-19 ONWARDS

Passed in the Board of Postgraduate Studies Meeting

Department of Nanotechnology

University of Kashmir

on

17th October, 2018

As per the latest Choice based Credit System (CBCS)
Guidelines, University of Kashmir
(2018-19 onwards)

DEPARTMENT OF NANOTECHNOLOGY

UNIVERSITY OF KASHMIR
SRINAGAR-190006

MASTERS (M.Sc.) PROGRAM IN NANOTECHNOLOGY

COURSE STRUCTURE TO BE IMPLEMENTED FOR STUDENTS ADMITTED FROM THE ACADEMIC SESSION 2018-19 ONWARDS UNDER CHOICE BASED CREDIT SYSTEM EXAMINATION PATTERN

The syllabus and courses of study for interdisciplinary Post-Graduate Degree program-M.Sc. in Nanotechnology, will be based on 96-credits. All the 96-credits will be spread over 4 semesters and shall include 5 different components of 'Teaching' *viz*., (i) Theory lectures (ii) Tutorials, (iii) Seminars, (iv) Two Laboratory Courses (one each in the second and third semester), and (v) Project- Research Based. Each semester will consist of a minimum of 24-credits including the 12-16 credits of Core and 8-credits of Discipline Centric Courses, both being compulsory. Remaining credits will be earned by students from OE/GE offered by other Departments. Nanotechnolgy Department will offer atleast two Generic elective/ Open elective courses of 2-credits in each semester for students enrolled in other PG Programs/ Departments of the University of Kashmir.

Course Structure: In each semester, there will be Core courses of 4 credits each, and in adddition 1-2 Core courses of 2 credits each- worth a total of 12-16 credits, referred to as MSNT-CR. In addition, students will earn 8-credits from the compulsory Discipline Centric (DCE) courses, referred to as MSNT-DCE. Further, Department of Nanotechnology will offer GE courses referred to as MSNT-GE that will be open to all students from other relevant subjects (Biological, Physical and Material Science) and OE courses referred to as MSNT-OE that will be open to students from all other Faculties/Schools, so that they may seek knowledge from other subjects, which is expected to nurture student's proficiency and skill.

M. Sc. Degree program in Nanotechnology will therefore comprise a total of 96-credits. Out of these, 56-credits will be earned by students from Compulsory Core Courses, 32-credits from Compulsory DCE Courses and remaining 8-credits from OE/GE offered by other Programs/ Departments of University of Kashmir under CBCS scheme.

Course-Credit break up for each semester will be as:

CREDITS	COURSE				TOTAL
	COMPULSORY		CHOICE BASED		
	CORE	DCE	GE	OE	
Minimum Credits	12	8	2	2	24

Each **CR** course offered by the Department of Nanotechnology will be worth of 100 marks and 4-credits/ worth of 50 marks and 2-credits. In addition, each **DCE** course offered by the Department will also be worth 100 marks or 50 marks for a 4-credit or a 2-credit course respectively. **Each** Laboratory Course (practicals) of 4-credits, will be worth 100 marks. Assessment of these will be based on student's performance during practical periods and external examination of at the end of semester. The students will be required to submit their lab. work records at the end of semester examination for evaluation by the examiner/teacher(s) concerned. Each **GE and OE course** will be worth 50 marks and 2-credits. Mode of examination and break-up of marks of various components for theory and practical courses will be the same as approved by the competent authority, and in accordance to what shall be in-vogue for the respective academic session/s.

A Research Based Project/ Internship (CR) in 4th semester worth 200 marks and 8-credits will be undertaken by the students In addition to Laboratory Courses (practicals) of 4-Credits each in 2nd and 3rd semesters. The students will be, assigned mentors as per their choice/ and or availibility of specialization, and work in the Department of Nanotechnology or at any Laboratory of repute outside the State. The project shall be submitted before the conduct of examination so that it can be evaluated and *viva voce* be conducted prior to declaration of the results.

M.Sc. Degree Program in Nanotechnology Department of Nanotechnology, UOK (Compulsory Courses)			
Paper		Subjects	Credits
Semester I	Core-1	Essentials of Nanoscience & Nanotechnology	4
	Core-2	Concepts in Solid State Physics	4
	Core-3	Cell & Molecular Biology	4
	Core-4	Elements of Spectroscopy	2
	DC-1	Carbon Nanostructures & Porous Materials	2
	DC-2	Genetic Engineering	2
	DC-3	Introduction to Mathematics-I	2
	DC-4	Advanced Techniques	2
Semester II	Core-1	Synthesis of Nanomaterials: Physical & Chemical Approaches	4
	Core-2	Characterization Methods of Nanomaterials	4
	Core-3	Human Physiology & Disease	4
	Core-4	Concepts in Nanophysics	2
	Core-5	Introduction to Electronics	2
	DC-1	Nanotechnology Laboratory Course-I	4
	DC-2	Introduction to Mathematics-II	2
	DC-3	Nanobioscience & Therapeutics	2
Semester III	Core-1	Nanomaterials: Properties & Applications	4
	Core-2	Nanoelectronics: Sensors & Devices	4
	Core-3	Nanomedicine: Therapeutics & Diagnostics	4
	Core-4	Seminar & Research Methodology	2
	DC-1	Nanotechnology Laboratory Course-II	4
	DC-2	Nanomedicine-II: Biomedicine, Current Status & Challenges	2
	DC-3	Environmental Nanotechnology	2
Semester IV	Core-1	Project Proposal Writing	4
	Core-2	Project-Research Based	8
	DC-1	Project Presentations	4
	DC-2	Laboratory Bio Safety Course	2
	DC-3	Viva-Voce	2
Total Credits			90

M.Sc. Degree Program in Nanotechnology
Department of Nanotechnology, UOK
SCHEME OFExamination under CBCS pattern

Paper		Subjects	Credits	L	T	P
Semester - I	MSNT101-CR	Essentials of Nanoscience & Nanotechnology	4	4		
	MSNT102-CR	Concepts in Solid State Physics	4	4		
	MSNT103-CR	Cell & Molecular Biology	4	4		
	MSNT104-CR	Elements of Spectroscopy	2	2		
	MSNT105-DCE	Carbon Nanostructures & Porous Materials	2	2		
	MSNT106-DCE	Genetic Engineering	2	2		
	MSNT107-DCE	Introduction to Mathematics-I	2	2		
	MSNT108-DCE	Advanced Techniques	2	2		
	OE/GE	Courses offered for other Departments	4	4		
Semester - II	MSNT201-CR	Synthesis of Nanomaterials: Physical & Chemical Approaches	4	4		
	MSNT202-CR	Characterization Methods of Nanomaterials	4	4		
	MSNT203-CR	Human Physiology & Disease	4	4		
	MSNT204-CR	Concepts in Nanophysics	2			
	MSNT205-CR	Introduction to Electronics	2	2		
	MSNT206-DCE	Nanotechnology Laboratory Course-I	4			8
	MSNT207-DCE	Introduction to Mathematics-II	2	2		
	MSNT208-DCE	Nanobioscience & Therapeutics	2	2		
	OE/GE	Courses offered for other Departments	4	4		
Semester- III	MSNT301-CR	Nanomaterials: Properties & Applications	4	4		
	MSNT302-CR	Nanoelectronics: Sensors & Devices	4	4		
	MSNT303-CR	Nanomedicine-I: Therapeutics & Diagnostics	4	4		
	MSNT304-CR	Seminar & Research Methodology	2	2		
	MSNT305-DCE	Nanotechnology Laboratory Course-II	4			8
	MSNT306-DCE	Nanomedicine-II	2	2		
	MSNT307-DCE	Environmental Nanotechnology	2	2		
	OE/GE	Courses offered for other Departments	4	4		
Semester- IV	MSNT401-CR	Research Proposal Writing	4	2	2	
	MSNT402-CR	Project- Research Based	8			16
	MSNT403-DCE	Project Presentations	4			
	MSNT404-DCE	Laboratory Bio-Safety Course	2		2	
	MSNT405-DCE	Viva-Voce	2			
	OE/GE	Courses offered for other Departments	4	4		
		TOTAL	96			

Table of Contents

Core Courses for Semester - I

MSNT101-CR	Essentials of Nanoscience and Nanotechnology
4 Credits	

Unit-I

Nanoscience and Nanotechnology: Background history, introduction and definition with suitable examples. Scale of materials – macro, micro and nanoscale. Difference between nanoscience and nanotechnology and its interdisciplinary nature. Feynman's vision of nanoscience and nanotechnology. Importance and emergence of nanotechnology in various sectors. Tools of Nano (evolution of nanotechnology). Grand challenges facing nanoscience and nanotechnology.

Unit-II

Materials and their types. Crystalline solids: close packed structures, unit cells, two- and three-dimensional Bravais lattices, crystal systems, crystal planes and Miller indices, symmetry elements in crystals, point groups and space groups, Introduction to nanomaterials, natural and synthetic nanomaterials. Classification of nanomaterials: zero-dimensional (clusters), one-dimensional (nanowires), two-dimensional (thin films and graphene) and hierarchical nanomaterials, examples from each class of nanomaterials. Basic synthetic strategies for nanomaterial synthesis.

Unit-III

Nanosize effects- surface to volume ratio (surface effects) and quantum confinement effect. Size dependent physical phenomena in semiconductor quantum dots and metal nanoparticles. Surface plasmon resonance and its dependence on various factors. Surface energy of nanomaterials, surface-energy minimization modes in nanomaterials. Quantum size effects and scaling laws. The material continuum.

Unit-IV

Variation in physical properties of nanomaterials in comparison to bulk materials: Lattice constants and melting point. Optical and mechanical properties of nanomaterials and their size dependence. Effect of size on electrical conductivity: surface scattering, change of electronic structure, quantum transport and effect of microstructure. Ferroelectrics, dielectrics and superparamagnetism.

Books Recommended

- *Hornyak, Dutta, Tibbals and Rao, Introduction to Nanoscience and Nanotechnology, New York, CRC press, 2008.*
- *Nanoscience and Nanotechnology in Engineering, VK Vardan, AS Pillai, Debashhish Mukherjee, Mayank Divedi, Linfeng Chen.*
- *Introduction to Nanoscience, SM Lindsay*
- *Introductory Nanoscience, physical and chemical concepts, Masaru Kuno.*
- *Nanostructures and Nanomaterials by Robert Koch*
- *Solid State Chemistry and its Applications by AR West.*

MSNT102- CR	Concepts in Solid State physics
4 Credits	

Unit-I

Crystal Physics: Bonding in crystal - cohesive energy, Defects in crystals: Point defects (Frenkel & Schottky), line defects (slip, plastic deformation, edge dislocation, screw dislocation, Burger's vector, concentration of line defects, estimation of dislocation density), dislocation multiplication (dislocation reaction), surface (Planar) defects, grain boundaries and stacking faults. Crystal structure determination: X-ray, electron and neutron diffraction, Ewald construction, Reciprocal lattices and its applications to diffraction techniques.

Unit-II

Lattice vibration and thermal properties: Einstein and Debye models; continuous solid; linear lattice; acoustic and optical modes; dispersion relation; attenuation; density of states; quantization of lattice vibrations, the concept of phonons and quantization; phonon momentum, Inelastic scattering of neutrons by phonons, Surface vibrations. Brillouin zones; thermal conductivity of solids. Thermal expansion.

Unit-III

Electronic Properties of Solids: Boltamann's transport equation, electrical and thermal conductivities of solid, Wiedemann-Franz law, Free electron theory of metals; Electrons in periodic lattice: Bloch theorem, the Kronnig Penny model, band theory, classification of solids on the basis of band theory, effective mass of electron and hole, Fermi surface and Fermi gas, Semiconductors – carrier concentration and fermi level and extrinsic and intrinsic, Transport phenomenon in semiconductor - Hall Effect.

Unit-IV

Optical and Dielectric properties of solids: Scattering, transmission and absorption in solid. optical properties of semiconductors, optical transitions, excitons, activators, Franck-Condon principle, colour centres, photoluminescence and thermoluminescence. Polarization, dielectric constants, Clausius-Mossotti equation, sources of polarization, frequency dependent of dielectric constants, ferroelectrics and piezo-electrics.

Superconductivity: critical temperature, type-I and type II superconductors, persistent current, effect of magnetic fields, Meissner effect, Josephson junction, Cooper pairs, BCS theory; Energy gap; high T_c superconductors, applications of superconductors.

Books Recommended

- *Introduction to Solid State Physics by C. Kittel.*
- *Solid State Physics – A.J. Dekker.*
- *Introduction to Solid State Physics – H.P. Myers.*
- *Solid state Physics – N.N. Ashcroft and N.D. Mermin.*
- *Solid state theory – F. Seitz.*
- *Solid State Theory – W. Harrison.*

MSNT103-CR	Cell and Molecular Biology
4 Credits	

Unit-I

Biomolecules: Carbohydrates- Structure, classification and reactions. Proteins: Amino acids and peptides-classification, structure of proteins, conformation of proteins and polypeptides. Enzymes: Enzyme kinetics, Regulation of enzymatic activity, Coenzymes: activators and inhibitors. Lipids: Classification, structure and functions. Nucleic acids: DNA as a genetic material, Building blocks of DNA, Various forms of DNA.

Unit-II

Metabolism: Glycolysis and TCA cycle; Glycogen breakdown and synthesis; Gluconogenesis; interconversion of hexoses and pentoses: Co-ordinated control of metabolism; Biosynthesis of purines and pyrimidines; Oxidation of lipids; Biosynthesis of fatty acids.

Unit III

Molecular Biology: General features of DNA replication: Initiation, Elongation and Termination of Replication, Transcription in prokaryotes and eukaryotes, Translation: Protein synthesis and genetic code, Positive and negative regulation of translation, post translational modifications.

Unit-IV

Cell Biology: Structure and function of cells in prokaryotes and eukaryotes; Structure and organization of Membrane - Model membranes, Glyco conjugates and proteins in membrane systems; Response to stress - active and passive, transport channels and pumps, Neurotransmission, neuromuscular junction. Extra cellular matrix – cell to cell and cell matrix adhesion – selectins, Integrins, cadherins, gap junctions. Mechanism of cell division: regulation of cell cycle; factors and genes regulating cell cycle.

Books Recommended

- *Principles of Biochemistry, Nelson, Cox, Lehninger*
- *R. Cantor, P. R. Samuel, —Biophysical Chemistry, W.H Freeman & Co., 1985.*
- *Watson, James, T. Baker, S. Bell, A. Gann, M. Levine, and R. Losick.*
- *Molecular Biology of the Gene‖, 5th ed., San Francisco: Addison-Wesley, 2000.*
- *Molecular Biology by Robert F Weaver: McGraw-Hill Higher Education.*
- *Lewin gene XI by Jocelyn E Krebs, et al: Jones and Bartlett Learning*
- *Molecular Cell biology by Harvey Lodish, W.H Freeman 2016.*

MSNT104-CR	Elements of Spectroscopy
2 Credits	

UNIT-I

Electromagnetic radiation characteristics, quantization of energy, regions of electromagnetic spectrum and representation of spectra, signal to noise ratio: resolving power. Width and intensity of spectral transitions.

Electronic absorption spectroscopy, types of transitions and selection rules, Franck-Condon principle. Emission spectra. Radiative energy-transfer processes: Fluorescence and Phosphorescence. *Jablonski* diagram. Some applications of UV-Visible spectroscopy.

UNIT-II

Infrared spectroscopy, Infrared spectrum, The functional group and fingerprint regions, Characteristic IR absorption bands, Intensity and position of absorption bands. Interpretation of an IR spectrum (examples).

Introduction to NMR Spectroscopy, physical basis of NMR. FT-NMR. ^{1}H NMR spectroscopy, Shielding and desheilding of protons. Signals in an ^{1}H NMR spectrum and chemical shift. Relative position of ^{1}H NMR signals. Diamagnetic anisotropy. Signal splitting (multiplicity) and coupling constants. Examples of ^{1}H NMR spectra. Introduction ^{13}C NMR spectroscopy.

Books Recommended

- *Fundamentals of Molecular Spectroscopy by CN Banwell and EM McCash*
- *Modern Spectroscopy by J. Michael Hollas*
- *Organic Spectroscopy by William Kemp*
- *Organic Chemistry by Paula Y. Bruice*

Discipline Centric Courses for Semester – I (Compulsory)

MSNT105-DCE	Carbon Nanostructures and Porous materials
2 Credits	

Unit-I

Carbon based nanomaterials- Carbon Nanotube (CNT), Graphene- History of the discovery of CNT's. Idealized and real structure of CNTs, Carbon Nanofoam and Buckminster Fullerenes. Applications of Carbon Nanotubes Tubes and their composites, Applications of Fullerenes and Graphene. Carbon Nanofoam and their applications. Toxiciy issues associated with Carbon based nanomaterials.

Unit-II

Micro and Mesopores Materials, Nanoporous materials – Silicon - Zeolites, mesoporous materials - nanomembranes and carbon nanotubes - AgX photography, smart sunglasses, transparent conducting oxides –molecular sieves – nanosponges. activated carbon, Aerogels and their types, Metal-Organic Frameworks (MOF's).

Books Recommended

- *The Physics & Chemistry of Nanosolids by Frank J. Owens and Charles P. Poole Jr., John Wiley & Sons, 2008*
- *Carbon Nanotubes: Properties and Applications- Michael J. O'Connell*
- *Carbon Nanomaterials for Environmental and Biological Applications, Bergmann and Machado, Springer.*
- *Graphene: Carbon in Two Dimensions (1st Edition) by Mikhail I. Katsnelson*
- *Carbon Nanostructures by O. A. Shenderova, V. V. Zhirnov & D. W. Brenner, Critical Reviews in Solid State and Materials Sciences. Volume 27 (2002)*

MSNT106-DCE	Genetic Engineering
2 Credits	

Unit -I

Recombinant DNA Technology Tools**:** Restriction endonucleases, DNA ligases, DNA phosphatases and their role in recombinant DNA technology, Vectors: Plasmids: General features of plasmid vectors. Characteristics features of pBR322, General scheme of cloning in plasmid vectors. Transformation of plasmid DNA in bacterial cells (Physical and chemical methods). Bacteriophages as cloning vectors, Phagemid vectors, Cosmid vectors, YACs and BACs.

UNIT-II

Genetic engineering and Applications: Introduction to animal cell culture and applications, Expression and purification strategies of fusion proteins. Expression in bacteria and yeast: Inducible expression systems in yeast (Gal and CUP1 system). Expression in Insect cell line (Sf9/21): Baculovirus expression vectors. Expression in mammalian cells. Mammalian expression vectors. Yeast Hybrid systems: Two hybrids. Application of fluorescent proteins-GFP and YFP in colocalization studies, Gene Therapy: Viral vectors, Phage display and applications.

Books Recommended

- *Molecular Biotechnology - Principles and Applications of Recombinant DNA by Glick, Bernard R.; Pasternak, Jack J.; Patten, Cheryl L: ASM Press.*
- *Principles of Gene Manipulation and Genomics by Sandy B. Primrose, Richard Twyman: Blackwell Publishing.*

- *Principles & Techniques Biochemistry & Molecular Biology. Wilson & Walker. Cambridge University Press.*
- *Physical Biochemistry: Principles and Applications. David Sheehan. Wiley publishing house.*
- *Cell Imaging Techniques: Methods and Protocols edited by Douglas J. Taatjes, Brooke T. Mossman. Humana Press.*

MSNT107-DCE	Introduction to Mathematics-I
2 Credits	

Unit-I

Algebra of matrices: Transpose, Adjoint, determinant and inverse of a square matrix; Trace of a matrix; Types of matrices; Rank of a matrix; Characteristic equation, eigenvalues and eigenvectors; Solution to linear homogeneous and non-homogeneous equations using matrix methods; Cramer's rule and Gauss elimination method.

Unit-II

Limit and Continuity of a function; Basic concept of Differentiable and Integrable functions with simple examples; Differential equations; first order linear differential equations; Solution of DE's using method of separation of variables, integrating factors, Bernoulli's equation, exact differential equations; Homogeneous and non-homogeneous linear differential equations with constant coefficients.

Books Recommended

- *George Phillip Barker and Hans Schneider Matrices and Linear Algebra. Dover Publications, INC New York.*
- *Shanti Narayan, A Text Book of Matrices. S. Chand and Company.*
- *Shepley L.Ross, Differential Equations, 3rd Ed., John Willey and Sons, 1984*
- *H.T.H. Piaggo, Differential Equation, PHI New Delhi.*
- *Zafar Ahsan, Differential Equations and Their Applications, second edition, PHI, New Delhi*

MSNT108-DCE	Advanced Techniques
2 Credits	

Unit-I

Techniques-I: Mass spectroscopy and types, Chromatography: Theory of Chromatography. Chromatographic Resolution. Affinity Chromatography, Purification GST fusion and Poly (His) tagged fusion proteins. Centrifugation: Basic principles of centrifugation, Types of centrifugation. Ultra centrifugation, Flow Cytometry and Microscopy: Basic principles, methods and Applications.

Unit-II

Techniques-II: Electrophoresis and Blotting Techniques: Basic principles & types of electrophoresis; Blotting techniques: Southern; Northern, Western; and their applications, ELISA. Polymerase chain reaction, Reverse Transcription PCR (RT- PCR), Real-Time PCR: Principle and methodology and applications. DNA microarray: Principle and methodology.

Books Recommended

- *Principles & Techniques Biochemistry & Molecular Biology. Wilson & Walker. Cambridge University Press.*
- *Physical Biochemistry: Principles and Applications. David Sheehan. Wiley publishing house.*
- *Cell Imaging Techniques: Methods and Protocols edited by Douglas J. Taatjes, Brooke T. Mossman. Humana Press.*

Core Courses for Semester – II

MSNT201-CR	Synthesis of Nanomaterials: Physical and Chemical Approaches
4 Credits	

Unit-I

Nanomaterial synthesis- Fundamentals of growth and nucleation. Homogenous and heterogeneous nucleation. Strategies towards synthesis of nanomaterials. Top down and bottom-up approaches for the synthesis of nanomaterial. Different Classes of Nanoparticles, including Core/shell nanoparticles.

Unit-II

Nanomaterial synthesis by Physical methods- with suitable examples in each method: Inert gas condensation, Arc discharge, Ion sputtering, Laser ablation, Ball milling, Lithographic techniques, Pyrolysis and other methods, Spray Pyrolysis, Molecular beam epitaxy, Chemical vapor deposition method and other variants.

Unit-III

Nanomaterial synthesis by Chemical methods- with suitable examples: in each method: Metal nanocrystals by reduction, Solvothermal/hydrothermal route, Nanocrystals of semiconductors and other materials by arrested precipitation, Sonochemical and Microwave assisted synthesis, Micelles and microemulsions.

Unit-IV

Nanofibers synthesis by Electrospinning method- various parameters influencing nanofiber morphology, porosity and other characteristics. Synthesis of polyurethane, polypropylene and nylox-6 fibers. Organic nanoparticles, and their synthesis. Biomimetic synthesis of nanocomposite material and tissue engineering- Different routes for synthesis of tissue engineered materials.

Books Recommended

- *G. Cao, Nanostructures and Nanomaterials: Synthesis, properties and applications, Imperial College Press, 2004.*
- *C. N. R. Rao, A. Muller, A. K. Cheetham, The chemistry of nanomaterials: Synthesis, properties and applications, Wiley (2004).*

- *Hornyak, Dutta, Tibbals and Rao, Introduction to Nanoscience and Nanotechnology, New York, CRC press, 2008.*
- *Hod Lipson, Melba Kumran: The new world of 3D Printing. John Wiley & Sons, Inc.*
- *Arkadii Arinstein: Electrospun Polymer Nanofibers, Taylor & Francis*

MSNT202-CR	Characterization methods of Nanomaterials
4 Credits	

Unit-I

XRD – operational principle and applications. Nano Perspective. Peak broadening and crystallite size- The Scherrer equation**,** Electron probe characterization methods. Optics and resolution, Electron interaction with matter. Electron Microscopy (SEM, TEM) - operational principle and applications.

Unit-II

Electron probe microanalysis. Scanning probe microscopy (AFM, STM) - operational principle and applications, Other important electron probe methods: Auger electron spectroscopy, Low energy electron spectroscopy (LEED) and Energy electron loss spectroscopy (EELS).

Unit-III

Spectral characterization of nanomaterials. Spectroscopy – Raman, IR, UV-Vis - operational principle and applications. Photoluminescence (PL) Spectroscopy. X-ray photoelectron spectroscopy (XPS). Surface area and porosity, Particle size determination by light scattering and surface charge on nanoparticles (Zeta potential).

Unit-IV

Thermal analysis methods: Principle and Instrumentation of Thermogravimetry; Differential Thermal Analysis and Differential scanning calorimetry- Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions. Vibrating sample Magnetometer and Electrochemical Characterization measurements.

Books Recommended

- *J. Goldstein, D. E. Newbury, D.C. Joy, and C.E. Lym, "Scanning Electron Microscopy and X-ray Microanalysis", 2003.*
- *D. Williams and B. Carter, "Transmission Electron Microscopy - A Textbook for Materials Science", Plenum Press, New York, 2nd Edition, 2009*
- *Banwell C. N, Fundamental of molecular Spectroscopy, McGraw Hill, 1996.*
- *Hornyak, Dutta, Tibbals and Rao, Introduction to Nanoscience and Nanotechnology, New York, CRC press, 2008.*
- *Solid State chemistry, AR West*

MSNT203-CR	Human Physiology and Disease
4 Credits	

Unit-I

Major human physiologic Systems of current Interest for biomedical applications- for example, cardiovascular, endocrine, nervous, gastrointestinal, and respiratory system. Various aspects of normal functioning of these systems & relationship to common pathologies from a diagnostic, assessment and management perspective. Human Genetic Diseases, Metabolic disorders in humans-Diabetes

UnitI-II

Immunity & Pathogenesis: Natural Molecular Recognition, Innate Immune System, Adaptive Immune System, Cells of Immune system, Cytokines, Antigens, MHC restriction, Cell mediated cytotoxicity: Mechanism of T cells and NK cell mediated lysis, ADCC and macrophage mediated cytotoxicity. Infection & Immunity: Immune response against parasitic and viral infections; Hybridoma Technology for monoclonal antibodies- Application of Monoclonal antibodies as therapeutics for various diseases; Tumor immunology, Immunotherapy for cancers.

Unit II

Cell signalling, the basic elements of cell signalling. Signalling molecules and their receptors Functions of G-protein- coupled receptors and their second messengers Protein \phosphorylation and its role in signal transduction Cytokine Receptors. Role of calcium and NO as an intracellular messenger. Detailed mechanism of signalling in the following pathways: GPCR pathway, RAS, MAPK pathway, PI3 Kinase Pathway

Unit-IV

Cancer Biology, The nature of cancer, causes of cancer, cellular oncogenes, Tumour suppressor genes, Properties of cancer cell, Hallmarks of cancer, cell immortalization and tumorigenesis, Insensitivity to antigrowth signals, Evading Apoptosis (Anoikis), Angiogenesis, Tissue invasion and metastasis, Conventional chemotherapy drugs their mechanism and limitations.

Books Recommended

- *Textboolk of Medical Physiology by Guyton and Hall*
- *Essential immunology by Roitt /Kuby*
- *How immune system works by Lauren Sompayrac.*
- *The Breakhthrough: Immunotherapy and the race to cancer by Charles Graeber*
- *Cancer Immunotherapy: Immune Supression and Tumor Growth by G. C, Prendergst.*
- *Text book of Cell Signalling in Cancer . Am educational approach by Jacques Robert*
- *Biochemistry of sinal transduction and regulation by Gerhard Krauss*
- *The biochemistry of cell signalling by Ernest Helmreich*
- *The biology of cancer by Rober A, Weinberg.*

MSNT204- CR	Concepts in Nano scale physics
2 Credits	

Unit-I

Electronic Structure of ID Systems, ID Sub-bands, Spectroscopy of Van-Hove Singularities, ID Metals-Coulomb Interactions and Lattice Couplings, Electrical Transport in ID, Conductance Quantization and the Landauer formula, Two barriers in series-resonant Tunneling, Incoherent Addition and Ohm's law, Voltage Probes and the Buttiker-Landauer formalism.

Unit-II

Quantization in Semiconductor Nanocrystals, Metallic Dots, Discrete Charge States, Coulomb Oscillations, Spin, Mott insulators, and the Kondo Effect, Cooper pairing in superconducting Dots, Vibrational and thermal properties of Nanostructures, Quantized Vibrational Modes, Transverse Vibrations, Heat capacity and Thermal Transport.

Books Recommended

- *Introduction to Solid State Physics by C. Kittel.*
- *Solid State Physics – A.J. Dekker.*
- *Introduction to Solid State Physics – H.P. Myers.*
- *Solid state Physics – N.N. Ashcroft and N.D. Mermin.*
- *Solid state theory – F. Seitz.*

MSNT205-CR	Introduction to Electronics
2 Credits	

Unit-I

Semiconductor bandgap Engineering, Junction (PN, MS) diode analysis and its applications,

Unit-II

Transistors (BT, MESFET, MOSFET) and its applications, CMOS technology with design examples.

Books Recommended

- *Microelectronics circuits by Sedra & smith,*
- *Electronic Devices & circuit Theory By Bolysted.*
- *Physics and Technology of Semiconductor Devices A. S. Grove, John Wiley and Sons,*
- *Solid State and Semiconductor Physics by Mc Kelvey*
- *Floyd, "Digital Fundamentals", Pearson Pub.*

Discipline Centric Courses – Semester – II (Compulsory)

MSNT206-DCE	Nanotechnology Laboratory Course-I
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-I (Practical's)**

1. Basic laboratory apparatus, handling, lab safety and protocols.
2. Sol-gel synthesis of nanomaterials.
3. Microemulsion based synthesis of nanomaterials.
4. Synthesis of ZnO nanoparticles and determining its Band Gap.
5. Hydrothermal/solvothermal synthesis of nanomaterials.
6. Synthesis of nanomaterials by a wet-chemical method (Noble metal, ZnS, Mn:ZnS).
7. Microwave-assisted synthesis of noble-metal nanoparticles and their optical properties.
8. Synthesis of nanocomposites using a solid state reaction.
9. Agarose Gel electrophoresis and Quantification of DNA and RNA.
10. Enzyme assay determination of specific activity of enzyme.
11. Determination of molecular weight of a protein by SDS-PAGE.
12. Western Blotting.
13. Immunoprecipitaion (IP).
14. GST protein expression and purification.
15. Animal Cell Culture & Flourescence Microscopy.
16. Media Preparation, Competent cell preparation and Bacterial Transformation.
17. Gene Cloning: Plasmid Isolation, Restriction digestion, PCR gene amplification

MSNT207-DCE	Introduction to Mathematics-II
2 Credits	

Unit-I

Laplace Transforms: Linearity property, first and second translation property of LT – Derivatives of Laplace transforms – Laplace transform of integrals – value theorems; Methods for finding LT: direct and series expansion method, Method of differential equation; Inverse Laplace transforms: Linearity property, first and second translation property, Convolution property – Application of LT to differential equations and boundary value problems.

Unit-II

Fourier Series and Integrals Fourier series definition and expansion of a function – Drichlet's conditions – Assumptions for the validity of Fourier's series expansion and its theorems – Complex representation of Fourier series - Problems related to periodic functions – graphical representation of FS – Fourier integrals - convergence of FS – some applications of Fourier transforms.

MSNT208-DCE	Bionanoscience & Therapeutics
2 Credits	

Unit-I

Levels of organization in living systems: Top Down to Bottom Up, Cellular processes at nanoscale; Nanoparticles in Medicine, Biological synthesis of nanomaterials/ Green synthesis- Use of biological systems like fungi, plants, purified enzymes and biological templates for synthesis of nanomaterials - Protein-Based Nanostructure Formation - DNA-Templated Nanostructure Formation - Protein Assembly.

Unit-II

Conventional Routes of administration of Drug; adsorption enhancement / solubility factor/ bioavailability, Chemical modification of proteins/ therapeutics, Combinatorial Synthesis: Chemistry, Biology, and Biotechnology, Drug Metabolism: Oxidation, reduction, hydrolysis, and conjugation. Need for developing new drugs: Procedure followed in drug design, Assay systems and models. Pre-clinical to clinical testing: Challenges and Future Perspectives.

Books Recommended

- *Hornyak, Dutta, Tibbals and Rao, Introduction to Nanoscience and Nanotechnology, New York, CRC press, 2008.*
- *Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge, UK (2005).*
- *Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Guozhong Gao, Imperial College Press (2004).*

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 tunneling- 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–color 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 nonintensivity – 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 (Synaphic) 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 nanosensor, Nanowire biosensor- as diagnostic tool in bio-medical applications,

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 Vo-Dinh, 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 form 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 acetylacetones 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-biointerface: 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 Avademic press.*
- *Stem cells: a revolution in therepautics-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 & Therepeutics.*
- *Ferreira, L. et al. New opportunities:2008 The use of nanotechnologies to manupulate 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 Vo-Dinh, 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 TiO_2, 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)*

Core Courses for Semester – IV

MSNT401-CR 4 Credits	Research Proposal writing

MSNT402-CR 8 Credits	Project-RESEARCH BASED

Discipline Centric Courses for Semester – IV

MSNT403-DCE 4 Credits	Project Presentation

MSNT404-DCE 2 Credits	Laboratory Bio Safety Course- Self Study

Unit-I

Biosafety- Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India;

Unit-II

Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

Books Recommended

- *John E. Smith, Biotechnology,3rd Ed.Cambridge University Press..*
- *Tutorials.*

MSNT405-DCE 2 Credits	VIVA-VOCE

Following are the proposed OE/GE Courses offered by the Department of Nanotechnology as part of M.Sc. Nanotechnology syllabus 2018-19 onwards for students enrolled in others Departments of University of Kashmir under CBCS System.

SEMESTER-I

OE/GE Courses offered by the Department of Nanotechnology for PG students enrolled in other Departments/Faculties			
COURSE CODE	**PAPER**	**CREDITS**	**INSTRUCTORS**
NTE18001OE	Nanoscience & Nanotechnology: An Introduction	2	Dr. Shafaquat Majeed
NTE18002OE	Introduction to Nanobiotechnology: Concepts and Applications in Health and Medicine	2	Dr. Tariq Maqbool

SYLLABUS			
COURSE CODE	**PAPER**	**CREDITS**	**INSTRUCTORS**
NTE18001OE	Nanoscience & Nanotechnology: An Introduction	2	Dr. Shafaquat Majeed

Unit-I

Nanoscience and Nanotechnology: History, definitions, nano scale and nano effects. Simple introduction and definition with suitable examples.

Nanomaterials, classification and properties: One-dimensional, Two-dimensional and Three-dimensional nanomaterials with examples from each class.

Unit-II

Nanomaterial Synthesis Strategies. Fundamentals of growth and nucleation. Top Down and Bottom up approaches for nanomaterial synthesis.

Photolithography, Chemical Etching, Laser Ablation, Ball milling, Solvothermal/Hydrothermal, Sol-gel route, chemical vapour deposition, Sonochemical and Microwave-irradiation assisted synthesis.

Books/Reference Recommended:

1. Charles P. Poole. Jr. & Frank J. ownes, Introduction to Nanotechnology - John Wiley & sons Inc. Publishers-2006
2. Guozhong Cao, Nanostructures and Nanomaterials: Synthesis, properties and applications-Imperial College press.

SYLLABUS			
COURSE CODE	PAPER	CREDITS	INSTRUCTORS
NTE18002OE	INTRODUCTION TO NANOBIOTECHNOLOGY: CONCEPTS AND APPLICATIONS IN HEALTH AND MEDICINE	2	DR. TARIQ MAQBOOL

Course Description:

Nanobiotechnology is a new frontier for biology with important applications in healthcare and medicine. It bridges areas in physics, chemistry, and biology and is a testament to the new areas of interdisciplinary science that are becoming dominant in the twenty-first century. This course will provide perspective for students who are interested

in science and technology at nanoscale, biological systems and their application in medicine.

Unit I

Introduction to Nano-Sciences and Technology:

- Concepts and processes in Nanotechnology
- Properties of matter at Nanoscale
- Examples of Nanostructures in nature
- Commercial Nanomaterials

Unit II

Application of Nanotechnology in Healthcare and Medicine:

- Biological systems at nanoscale.
- Medical Innovation.
- Nanomedicine; Convergence of Nanoscience and systems biology.
- Applications of Nanotechnology in Healthcare and Medicine:
- Role of biosensors in diagnostics and Drug discovery.
- Targeted therapeutics and molecular imaging.
- Novel therapeutics and Drug delivery systems.
- Safety and Toxicological issues.

Books/Reference Recommended:

1. *Hornyak, Dutta, Tibbals and Rao, Introduction to Nanoscience and Nanotechnology, New York, CRC press, 2008.*
2. *Nanobiotechnology: Concepts, Applications and Perspectives by Christof M.*
3. *Niemeyer and Chad A. Mirkin.*
4. *Targeted Drug Delivery concepts by P. V. Devarajan, S. Jain.*
5. *Nanobiotechnology and nanobiosciences by Claidio Nicolini.*

SEMESTER-II

OE/GE Courses offered by the Department of Nanotechnology for PG students enrolled in other Departments/Faculties			
COURSE CODE	**PAPER**	**CREDITS**	**INSTRUCTORS**
NTE18003OE	Targeted Drug Delivery	2	Dr Mushtaq A Beigh
NTE18004OE	Tissue Engineering	2	Dr. Faheem A Sheikh

SYLLABUS			
COURSE CODE	**PAPER**	**CREDITS**	**INSTRUCTORS**
NTE18003OE	Targeted Drug Delivery	2	Dr Mushtaq A Beigh

Unit I

Nano-medicine: Nanoparticle delivery systems, characteristics, applications and advantages. Targeted drug delivery: (e.g., DNA, RNA, protein, drug) in therapeutic applications, Use different nanomaterials as drug carriers and imaging agents. Novel Therapeutic Delivery Systems. Liposome and Microsphere Transport and Delivery.

Unit II

Recent advancement in Nano-biointerface: 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. Drug targeting to tumours. Targeting the Vasculature of Solid Tumours. Drug Delivery to the Brain.

Books/Reference Recommended:

1. *Targeted drug delivery: Concepts and design: by Padma V. Devrajan, Springer Press*
2. *Drug delivery systems: Ranade-Cannon-Third edition, CRC press*

SYLLABUS			
COURSE CODE	**PAPER**	**CREDITS**	**INSTRUCTORS**
NTE18004OE	**TISSUE ENGINEERING**	**2**	**DR. FAHEEM A SHEIKH**

Unit I

History and fundamentals of tissue engineering. Different biomaterials for tissue engineering. Different routes for synthesis of tissue engineered materials (e.g., Nanofiber self-assembly, Textile technologies, Solvent casting and particulate leaching, Gas foaming, Emulsification freeze-drying, Thermally induced phase separation, Electrospinning, Laser-assisted bioprinting and 3D printing). Bone healing around implants (e.g., biomimetic coatings, nano titanium based implants). Scaffolding, Tissue culture, Bioreactors and Bioartificial organs

Unit II

Nanofiber production using specialized technique. Controlling morphologies of nanofibers. Polymer nanofibers and ceramic nanofibers for tissue engineering application. Bionics (Swim-suits with shark-skin-effect, soil repellence, lotus effect). Nano finishing in textiles (UV resistant, antibacterial, hydrophilic, self-cleaning, flame

retardant finishes, fragrance releasing cloths). Modern textiles (Lightweight bulletproof vests and shirts, color changing property, Waterproof and Germ proof, Cleaner kids clothes).

Books/Reference Recommended:

1. *Tissue Engineering, John P. Fisher , Joseph D. Bronzino , Antonios G. Mikos, Taylor & Francis Inc, ISBN10: 0849390265*
2. *Electrospinning: Materials, Processing, and Applications, Joachim H. Wendorff, Seema Agarwal, Andreas Greiner , Wiley ISBN: 978-3-527-32080-6*

SEMESTER-III

OE/GE Courses offered by the Department of Nanotechnology for PG students enrolled in other Departments/Faculties			
COURSE CODE	**PAPER**	**CREDITS**	**INSTRUCTORS**
NTE18005OE	Cancer Nanotechnology		Dr Mushtaq A Beigh
NTE18006OE	Applications of Nanotechnology in Food Sciences		Dr. Faheem A Sheikh

SYLLABUS			
COURSE CODE	**TITLE**	**CREDITS**	**INSTRUCTOR**
NTE17005OE	Cancer Nanotechnology	2	Dr. Mushtaq A Beigh

Unit I

Cancer and classical therapeutics: Cancer- General description, cancer cells and effector mechanisms, Tumor Dissemination (metastasis), Types and localization.

Current therapies, chemotherapy, radiotherapy and other biologicals-based therapies, cancer diagnostics- elementary idea

Problems with current therapies-tumor relapse

Unit II

Nanotechnology based cancer theranostics: Benefits of Nanotechnology for cancer treatment, passive tumor accumulation, Active tumor targeting, transport across tissue barriers,

Early detection and diagnosis- imaging *in vivo*, Sensing *in vitro*

Treatment and therapy- delivering targeted chemotherapy, Nano-enabled immunotherapy, Augmenting radiotherapy

Current nanotechnology Treatments, Approved cancer drug therapies based on Nanotechnology, Nano based therapeutics in clinical trials

Books/Reference Recommended:

1. *Targeted drug delivery: Concepts and design: by Padma V. Devrajan, Springer Press*
2. *Drug delivery systems: Ranade-Cannon-Third edition, CRC press*

SYLLABUS			
COURSE CODE	**TITLE**	**CREDITS**	**INSTRUCTOR**
NTE17006OE	APPLICATIONS OF NANOTECHNOLOGY IN FOOD SCIENCES	2	DR. FAHEEM A SHEIKH

Unit I

Introduction to nanoscale, Synthesis of different nanomaterials used in food (e.g., nanodispersions, nanocapsules, association colloids, nanoemulsions, biopolymeric nanoparticles, nanolaminates, nanofibers and nanotube) the enhanced material properties, method of processing and level of incorporation. Nano-sized additives used in food and nanomaterials for delivery of nutraceutical/functional ingredients. Nanosensors for pesticide, pathogen and toxin detection in food products. Nano-based food packaging materials, cleaning and disinfection, Safety issues and regulations for use of nanomaterials.

Unit II

Case studies based on: Delivery of nano-based antimicrobials. Packaging using edible coating, active packaging and intelligent packaging. Nanoencapsulation for bioactive delivery, flavor delivery and nutrient delivery. Enhancing physical properties for color additives, anticaking, improving the tensile strength, increasing the gas permeability, water resistance and flame resistance. Recent examples of nano additives (colors, flavoring agents, preservatives, antioxidants). Nano-starch, Nano-cellulose, Nano-salt, nano-mayonnaise, Ice-cream, Nanotea, Nano-SiO_2, Se, TiO_2, Fe, ZnO, Ag, Ca materials used in modern foods.

Books/Reference Recommended:

1. *Xiaojia He, Huey-MinHwang, Nanotechnology in food science: Functionality, applicability, and safety assessment, Journal of Food and Drug Analysis, 24, 2016, 671-681.*
2. *Neha Pradhan, Facets of Nanotechnology as Seen in Food Processing, Packaging, and Preservation Industry, BioMed Research International, Volume 2015, Article ID 365672, 17 pages.*

SEMESTER-IV

OE/GE Courses offered by the Department of Nanotechnology for PG students enrolled in other Departments/Faculties			
COURSE CODE	**PAPER**	**CREDITS**	**INSTRUCTORS**
NTE18001GE	Smart Materials	2	Dr. Shafaquat Majeed
NTE18002GE	Stem Cells & Regenerative Medicine	2	Dr. Tariq Maqbool

SYLLABUS			
COURSE CODE	**TITLE**	**CREDITS**	**INSTRUCTOR**
NTE17001GE	Smart Materials	2	Dr. Shafaquat Majeed

Unit-I

Introduction to materials, classification of materials, Historical perspective and time-line of major developmental efforts related to material science, Considerations in the design of new materials: critical thinking approach.

Unit-II

Definition of a smart material, different types of smart materials: shape-memory alloys (SMAs), piezoelectric materials, magnetostrictive materials, magneto- and electro rheological Materials, chromic materials: thermochromic and photochromic

Books/Reference Recommended:

1. *Material Chemistry by Bradley D. Fahlman*
2. *Smart Materials by Dr Daine Talbot (Institute of Materials, Minerals and Mining)*

SYLLABUS			
COURSE CODE	TITLE	CREDITS	INSTRUCTOR
NTE17002GE	STEM CELLS & REGENERATIVE MEDICINE	2	DR. TARIQ MAQBOOL

Course Description

Stem Cell and Regenerative Medicine course is designed as a generic elective course to give opportunity to students to learn about new, up to date technologies that are applicable to modern therapeutic approaches in biomedicine, such as: stem cell applications, nanomedicine, bioengineering-functionalized scaffolds, biomaterials.

Unit-I

- Current and Future Perspectives of Regenerative Medicine
- Biologic and Molecular Aspects of Regenerative Medicine
- Embryonic and Adult Stem Cells
- Induced Pluripotent Stem Cells

Unit-II

- Therapeutic applications of Stem cells
- Applications of Nanotechnology in stem cell research: tracking, delivery, scaffolds
- Nanoparticles as Nucleotide Delivery for Genetic Control in stem cells
- Biomaterials & bioprinting in Regenerative Medicine

Books/Reference Recommended

1. *R. Lanza. Gearhart et al (Eds), Essentials of Stem Cell Biology. 2009, Elsevier Avademic press.*
2. *Stem cells: a revolution in therepautics-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 & Therepeutics.*
3. *Ferreira, L. et al. New opportunities:2008 The use of nanotechnologies to manupulate and track stem Cells.*