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: Boltzmann'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 Tc 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; Gluconeogenesis; 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. 1H NMR spectroscopy, Shielding and deshielding of protons. Signals in an 1H NMR spectrum and chemical shift. Relative position of 1H NMR signals. Diamagnetic anisotropy. Signal splitting (multiplicity) and coupling constants. Examples of 1H NMR spectra. Introduction 13C 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*

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. Toxicity 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 – nano sponges. 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.*