# Draft syllabus

# M. Sc Nanoscience and Nanotechnology

# 2024

**Semester-I**

| Course Code | Course name | Credit point | Weekly hours (L+T+P) | Marks (Internal + end semester) |
|---|---|---|---|---|
| | **Theory** | | | |
| NSNT COR 101 | Fundamental chemistry | 4 | 3+1+0 | 50 (10+40) |
| NSNT COR 102 | Fundamental physics | 4 | 3+1+0 | 50 (10+40) |
| NSNT COR 103 | Fundamental biology | 4 | 3+1+0 | 50 (10+40) |
| NSNT COR 104 | Synthesis of nanomaterials | 4 | 3+1+0 | 50 (10+40) |
| NSNT COR 105 | Characterization of nanomaterials | 4 | 3+1+0 | 50 (10+40) |
| NSNT AECC 106 | Fundamentals of statistics | 2 | 2+1+0 | 25 (5+20) |
| **Total theory credit** | | **22** | | |
| | **Practical** | | | |
| NSNT COR 111 | Analytical chemistry | 2 | 0+0+2 | 25 (5+20) |
| NSNT COR 112 | Biophysical-chemistry | 4 | 0+0+4 | 50 (10+40) |
| NSNT COR 113 | Statistics | 2 | 0+0+2 | 25 (5+20) |
| **Total practical credit** | | **8** | | |
| **Cumulative credit & Marks of the semester** | | **30** | | **375** |

**Semester-II**

| Course Code | Course name | Credit point | Weekly hours (L+T+P) | Marks (Internal + end semester) |
|---|---|---|---|---|
| | **Theory** | | | |
| NSNT GEC 201 | Fundamentals of Nanotechnology | 4 | 3+1+0 | 50 (10+40) |
| NSNT COR 202 | Advanced chemistry for nanotechnology | 4 | 3+1+0 | 50 (10+40) |
| NSNT COR 203 | Advanced physics for nanotechnology | 4 | 3+1+0 | 50 (10+40) |
| NSNT COR 204 | Advanced biology for nanotechnology | 4 | 3+1+0 | 50 (10+40) |
| NSNT DSE 205 | *One elective from the following*<br>i. Nanocatalysis<br>ii. Molecular recognition & self-assembly<br>iii. Drug delivery | 2 | 2+1+0 | 25 (5+20) |
| NSNT DSE 206 | *One elective from the following*<br>i. Instrumental techniques- data analysis<br>ii. Quantum mechanics<br>iii. Informatics | 2 | 2+1+0 | 25 (5+20) |
| **Total theory credit** | | **20** | | |
| | **Practical** | | | |
| NSNT COR 211 | Nanotechnology lab-I | 4 | 0+0+4 | 50 (10+40) |
| NSNT COR 212 | Nanobiotechnology lab-I | 4 | 0+0+4 | 50 (10+40) |
| NSNT COR 213 | Computing lab-I | 2 | 0+0+2 | 25 (5+20) |
| **Total practical credit** | | **10** | | |
| **Cumulative credit & Marks of the semester** | | **30** | | **375** |

**Semester-III**

| Course Code | Course name | Credit point | Weekly hours (L+T+P) | Marks (Internal + end semester) |
|---|---|---|---|---|
| | **Theory** | | | |
| NSNT COR301 | Nanotechnology for efficient energy devices | 4 | 3+1+0 | 50 (10+40) |
| NSNT COR 302 | Nanoelectronics | 4 | 3+1+0 | 50 (10+40) |
| NSNT COR 303 | Nanotechnology in biology & healthcare | 4 | 3+1+0 | 50 (10+40) |
| NSNT COR 304 | Environmental and societal implication of Nanotechnology | 4 | 3+1+0 | 50 (10+40) |
| NSNT SEC 305 | Research Methodology and IPR law | 2 | 2+1+0 | 25 (5+20) |
| NSNT SEC 306 | Chemi-informatics and Bioinformatics | 2 | 2+1+0 | 25 (5+20) |
| **Total theory credit** | | **20** | | |
| | **Practical** | | | |
| NSNT COR 311 | Nanotechnology lab-II | 4 | 0+0+4 | 50 (10+40) |
| NSNT COR 312 | Nanobiotechnology lab-II | 4 | 0+0+4 | 50 (10+40) |
| NSNT COR 313 | Computing lab-II | 2 | 0+0+2 | 25 (5+20) |
| **Total practical credit** | | **10** | | |
| **Cumulative credit & Marks of the semester** | | **30** | | **375** |

**Semester-IV**

| Course Code | Course name | Credit point | Weekly hours (L+T+P) | Marks (Internal + end semester) |
|---|---|---|---|---|
| NSNT COR 401 | Project/Dissertation & presentation | 16 | NA | 200 |
| NSNT COR 402 | Review writing and presentation | 10 | NA | 125 |
| NSNT COR 403 | Grand viva | 4 | NA | 50 |
| **Cumulative credit & Marks of the semester** | | **30** | | **375** |

**Course code convention:** NSNT-W-XYZ; W= COR/AECC/GEC/DSE/SEC; X= Semester number 1/2/3/4; Y= Theoritical/Practical paper 0/1; Z= Paper code

**Semester wise credit distribution: Semester** I + Semester II + Semester III + Semester IV = 30 + 30 + 30 + 30=120

**Semester wise marks distribution:** Semester I + Semester II + Semester III + Semester IV = 375 + 400 + 375 + 350=1500

**COR:** Core courses**; AECC:** Ability Enhancement Compulsory Course**; GEC:** General Elective Courses**; SEC:** Skill Enhancement Courses**; DSE:** Discipline Specific Elective

# Semester-I

## Paper: Fundamental Chemistry (NSNT COR 101)

### Module I: Chemical bonds

The structural theory of organic chemistry, chemical bonds: the octet rule, writing Lewis structures, exceptions to the octet rule, formula charge, resonance, energy changes, quantum mechanics, atomic and molecular orbitals, The structure of methane- sp3, The structure of borane- sp2, The structure of beryllium hydride - sp hybridization, Molecular geometry: valence shell electron pair repulsion (VSEPR) theory. Polar covalent, polar and non polar molecules. Representations of organic compounds structural formulas.

### Module II: Chemical kinetics

Basic definitions, differential equation view of rate, rate constant, rate law, reaction order, $1^{st}$ and $2^{nd}$, Pseudo first order kinetics, maths of determination of kinetics from rate laws, half-life. Empirical determination of reaction order and reaction kinetics: initial rates, kinetic analysis, experimental methods. Reversible $1^{st}$ order equilibria: $K = k1/k-1$, relation to $\Delta G$.

### Module III: Basics of photochemistry

Theory of light absorption-electronic excitation-properties & energies of excited states- Jablonski diagram-photo physical processes-fluorescence and phosphorescene-excimers and exciplexes-intersystem crossing-energy transfer-geometry of excited states-quantum efficiency.

### Module IV: Transition and inner transition elements

Definition and electronic configurations of transition element, General characteristics of transition elements, comparison of first transition series with second and third series elements. Position of lanthanides and actinides in the periodic tables, general characteristics of both series and their comparisons. Basic concepts of coordination compounds: ligands (mono, di, and poly dentate ligand), chelation, coordination numbers and Nomenclature of coordination compounds. Nature of metal ligand bonding in complex, study by valence bond theory and crystal field theory.

### Module V: Polymers

Introduction and review of Polymer, Properties of polymers, Polymer additives: plasticizers, fillers and reinforcement: Polymer blends- toughen plastics and phase separated blends. Polymer composites- mechanical properties. Introduction to polymer nanocomposites: Basic materials for polymer nanocomposite. Characterization of polymer nanocomposites, Properties of polymer nanocomposites: Thermoplastic nanocomposites, Thermoset Nanocomposites, Elastomer Nanocomposites. Applications of polymer nanocomposites in: high temperature, paint formulation, Automobiles, Aerospace, Injection Molded Products.

## Paper: Fundamental Physics (NSNT COR 102)

### Module I: Atomic Structure

Electron orbits, The Bohr atom, Wave mechanical model, Schrodinger equation, Particle in a box, radial and angular distribution functions; Vector model of atom and electronic configuration of polyelectronic atoms; Effective nuclear charge; Slater's rules, penetration & screening effect. Quantum Structure: 2D (Quantum well), 1D (Quantum Wires), 0D (Quantum Dots).

**Module II: Statistical mechanics & Chemical kinetics**

Macroscopic description of systems of many particles – entropy and kinetics – The classical probability distribution for non-interacting particles – Entropy and the Boltzmann distribution: ions in a solution near an electrode – Fermi-Dirac distribution – The partition function – The partition function for an ideal gas – Free energy, pressure and entropy of an ideal gas from partition function –The Kramer's theory of reaction rates – Chemical kinetics – Acid – base reactions as an example of chemical equilibrium– Rate equations in small systems – Thermodynamics at Nanoscale.

**Module III: Solid state property**

Crystal structure –Periodic array of atoms – Lattice translation vectors – Basis and the crystal structure – Primitive lattice cell – Packing fraction - Fundamental types of lattices – Two and three dimensions –Index of crystal planes – Diffraction of waves by crystals – Bragg law – Reciprocal lattice vector – Diffraction conditions – Laue equations – Brillouin zones – Reciprocal lattice to *sc*, *bcc* and *fcc* lattices – Structure factor for *bcc* and *fcc* lattices – Atomic form factor. Nearly free electron model – Origin of the energy gap – Magnitude of the energy gap – Bloch functions – Kronig-Penney model – Wave equation of electron in a periodic potential – Restatement of the Bloch theorem – Crystal momentum of an electron –Kronig-Penney model in reciprocal space – Density of states for 1, 2 and 3 dimensional electron gas.

**Module IV: Thermodynamics**

Zeroth law of thermodynamics: Equilibrium and concept of temperature. First Law of thermodynamics: State and path functions, extensive and intensive properties, equation of state, work, heat, internal energy, heat capacity and concept of enthalpy. Second law of thermodynamics: Reversible and irreversible process, heat engines, Carnot cycle, statements of the second law, concept of entropy, free energy, criteria for equilibrium and stability. Third law of thermodynamics: Concept of the absolute zero temperature and Nernst heat theorem. Equilibrium thermodynamics: Chemical potential, Gibbs-Duhem equations, phase equilibrium, Clapeyron equation, Claussius-Clayperon equation, phase rule, phase diagram, phase transitions in one-component and multi-component systems, chemical equilibrium, interrelations between Kp, Kc and Kx, effect of temperature (van't Hoff equation) and pressure on equilibrium constant.

**Module V: Quantum Mechanics**

Basic postulates. Exactly sovable models in 1-D: Free particle, particle in a well, barrier models, SHO, angular momentum, Approximation methods: variation, perturbation methods. Simple idea of bonding. Simple model of nanomaterials: 0D, 1D, 2D particles.

# Paper: Fundamental Biology (NSNT COR 103)

**Module I: Structural biochemistry**

Structure and organization and functions of biomolecules; Carbohydrates, Lipids, Proteins and Nucleic acids. Enzymes- function and kinetics.

**Module II: Cell structure and function**
Universal features of cells; cell chemistry and biosynthesis: chemical organization of cells; Ultra Structure of prokaryotic cells- cell envelope; cell membrane; extra cellular appendages; cell inclusion. Internal organization of the cell - cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes. Cell signaling, cell death mechanisms, quorum sensing in bacteria.

**Module III: Molecular biology**
Central dogma- Replication, transcription, translation. Protein folding and localization.

**Module IV: Immunology**
History of immunology, Innate and acquired immunity, Hematopoiesis, Cells and organs of the immune system. B and T- cell activation. Phagocytosis – Oxygen dependent and Oxygen independent killing. Antigen -Properties of antigen. Antibody- structure and types. Hybridoma Technology.

**Module V: Recombinant DNA technology**
DNA manipulative enzymes (Nucleases, ligases, polymerases, modifying enzymes), Restrictions endonucleases, restriction mapping; different methods of formation of chimeric DNA – use of linkers, adaptors, homopolymers etc. Principle, dependence on oligonucleotide primers and temperatures, sequencing of PCR products, application of PCR (Chemical diagnosis, amplification of RNA through RT-PCR, RAPD analysis. Introduction of DNA into living cells. Vectors. Cloning.

# Paper: Synthesis of nanomaterial (NSNT COR 104)

**Module I: Chemical methods**

Synthesis of semiconductor nanoparticles, nanowires, quantum dots, nanoclusters, metal oxide nanoparticles- ZnO,$TiO_2$. Metal nanoparticle by reduction, Nanoparticle synthesis of different types of metals (Cu, Ag, Au, Pd, Pt), synthesis of nanoparticles having different size, shapes and facet selective synthesis.

**Module II: Conjugation chemistry**
Conjugation Chemistry Principles - Amine Reactions - Thiol Reactions - Hydroxyl Reactions - Carboxylic Acid Reactions - Aldehydes and Ketones Reactions - Alkenes and Alkynes - Photochemical Reactions - Biomolecules Conjugation Onto Self-Assembled Monolayers via

Covalent Binding - Biomolecules Conjugation on Self - Assembled Monolayers via Affinity Binding - Challenges in (Bio) conjugation.

**Module III: Physical methods**
Ball milling – Inert gas condensation technique(IGCT)–Thermal evaporation–Pulsed laser deposition(PLD)–DC/RF magnetron sputtering – Molecular beam epitaxy (MBE)–Melt spinning process –IC Fabrication process– Microlithography– Etching – Wet cleaning– CMP–Backend process – Atomic layer deposition (ALD).

**Module IV: Lithographic technique**
Introduction–Lithography–Photolithography – Phase-shifting photolithography – Electron beam lithography-X – ray lithography – Focused ion beam (FIB) lithography – Neutral atomic beam lithography – Nanomanipulation and nanolithography– Soft Lithography– Assembly of Nanoparticles and nanowires - Other methods for microfabrication.

**Module V: Biological methods**
Introduction-Natural nanocomposite materials – Biologically synthesized nanoparticles-Nanostructures and synthetic nanocomposites– Protein based nanostructure formation – DNA Template nanostructure formation- Protein assembly – Biologically inspired nanocomposites– Lyotropic liquid – Crystal templating – Liquid crystal templating of thin films – Block copolymer templating-Colloidal Templating.

## Paper: Characterization of nanomaterial (NSNT COR 105)

**Module I: Structural Chaaracterization**
Powder X-ray diffractometer - Synchrotron radiation – FTIR spectrometer – Raman Spectrometer - Stylus profilometer.

**Module II: Microscopic and Surface Analysis**
Electron microscopes: scanning electron microscope (SEM) – transmission electron microscope (TEM); Scanning Probe Microscopy: atomic force microscope (AFM) – scanning tunneling microscope (STM); Laser confocal microscope – Brunauer – Emmer – Teller Surface area analysis.

**Module III: Spectroscopy**
X-ray photoelectron spectrometer (XPS) – EDAX and WDA - Mass Spectrometer – Secondary Ion Mass Spectrometer (SIMS) –ICPMS - Nuclear magnetic resonance (NMR) – Electron spin resonance (ESR).

**Module IV: Electrical, Mechanical and Magnetic Properties**
Impedance Spectroscopy – Electro analytical Techniques: Potentiometry – Cyclic Voltammetry - Physical Property Measurement System (PPMS) –Nanoindentation – Vibrating sample magnetometer.

**Module V: Thermal and Optical Properties**

Differential scanning calorimeter (DSC) – Thermogravimetric/Diffferential thermal analyzer (TG/DTA) – UV – Visible spectrophotometer – Spectroflourometer – Contact angle measurement. Dynamic Light Scattering (DLS).

# Paper: Fundamentals of statistics (NSNT AECC 106)

**Module I: Introduction**
Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: tabular and graphic, including histogram and ogives.

**Module II: Measures of Central Tendency**
Mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.

**Module III: Bivariate data**
Definition, scatter diagram, simple and rank correlation. Simple linear regression, principle of least squares and fitting of polynomials, Applications.

**Module IV: Analytics & Infrantial Statics**
Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications. Discrete and continuous random variables, p.m.f., p.d.f. and c.d.f. Illustrations and properties of random variables. Mathematical Expectation and Generating Functions Expectation of single and bivariate random variables and its properties Binomial, Poisson, along with their properties and limiting/approximation cases.

**Module V: Hypothesis testing**
Definitions of random sample, parameter and statistic, Different kinds of sampling methods, Random versus non-random samplings, Probabilistic versus non probabilistic samplings. Sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Large sample tests for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical. p-value approaches, $\chi^2$ test, F test & t test with their properties and uses, ANOVA, MANOVA. Mann-Whitney, Sign, Median and Kruskal- Wallis tests (Non-parametric).

# Paper: Analytical chemistry (NSNT COR 111)

1. Estimation of carbonate and bicarbonate
2. Estimation of free alkali in soaps and detergent
3. Study of kinetics of acid catalyzed hydrolysis of methyl acetate
4. Estimation of acetic acid in commercial vinegar
5. Determination of partition coefficient of iodine between water and $CCl_4$

6. Determination of pH of unknown solution by color matching method

## Paper: Biophysical chemistry (NSNT COR 112)

1. Separation of amino acid by TLC
2. Quantitative analysis of amino acids
3. Protein estimation by Lowry, Bradford method
4. Total sugar, and reducing sugar estimation
5. pH metric titration of glycine for determination of pI
6. Ascorbic acid estimation from lemon juice
7. Quantitative estimation of nucleic acid
8. Saponification value measurement of lipid
9. Iodine value determination of fatty acid
10. Determination of solution concentration by absorption spectrometry

## Paper: Statistics (NSNT COR 113)

1. Graphical representation of data: Problems based on measures of central tendency; Problems based on measures of dispersion; Problems based on moments, skewness and kurtosis.
2. Fitting of polynomials, exponential Curves
3. Karl Pearson correlation coefficient; Spearman rank correlation with and without ties.
4. Correlation coefficient for a bivariate frequency distribution
5. Lines of regression, and estimated values of variables.
6. Exact Sample Tests based on Chi-Square Distribution.
7. Testing of few special tests for bio statistics using R & Python programming

# Semester-II

## Paper: Fundamentals of Nanotechnology (NSNT GEC 201)

**Module I: Basics of Nanoscience and Nanotechnology**
Chronological development of nanoscience and nanotechnology (NSNT). Important discoveries in NSNT. Idea about dimension – Light year to atomic scale. Basics of molecular spectroscopy. Basics of quantum mechanics. Atomic structure, band structure.

**Module II: Introduction to Nanomaterials**
Different types of nanomaterials: Metallic- Polymeric- Carbon- Metal Oxide- Core Shell. Overview on nanomaterial synthesis- physical, chemical and biological methods. Properties of nanomaterials-mechanical, electrical and optical.

**Module III: Tools and techniques of Nanoscience and Nanotechnology**
Spectral characterization: Absorption- Emission- Infra Red (IR) - Raman spectroscopy; X-ray diffraction; Structural characterization:- TEM- SEM; Surface characterization: STM- AFM.

**Module IV: Applications of Nanoscience and Nanotechnology**
Energy conservation and storage, Nanoelectronic devices, semiconductor nanodevices, solar cells, environmental remediation through nanoparticles, Nanoporous polymers and their applications in water purification, Biomedical Nanotechnology, Nanotechnology in Agriculture - Precision farming, Nanofertilizers-Nanourea and mixed fertilizers, Nanopesticides, Nanoseed Science. Nanotechnology in Food industry – Nanopackaging for enhanced shelf life.

# Paper: Advanced chemistry for nanotechnology (NSNT COR 202)

**Module I: Advanced Chemical Bonding**

Structure and Bonding: Review of basic principles of structure and bonding, application of acid base concepts, HSAB theory, aromaticity and antiaromaticity, Hückel's rule, anti-aromaticity, y-aromaticity, homo-aromaticity n-annulenes, heteroannulene, fullerenes, C-60, cryptates, Bonds weaker than covalent; addition compounds, inclusion compounds, crown ethers, cyclodextrins, catenanes and rotaxanes.

**Module II: Advanced Organic Chemistry**

Separation techniques and characterization (t.l.c, column, distillation, crystallization, GC etc.)
Organic synthesis: Representative reaction to be covered. Esterfication and saponification, Oxidation, Reduction, Nucleophilic substitution, Cycloaddition reactions, Grignard reaction, Condensation reactions, Preparation of dyes, Aromatic electrophilic substitution, Heterocyclic synthesis, Solidphase synthesis, Natural product extraction: Solasidine, Caffeine, Nicotine, Peptine, Rosine, Carotenoids, Computational methods of retro-synthetic analysis modeling and calculation.

**Module III: Organo-metalic chemistry**

History and perspective, definition of organometallic compound, classifications, nature of metal-carbon bond, nomenclature, the 18-electron rule, σ-bonded organometallic compounds, transition metal π-complexes of olefinic, acetylenic, allylic, acyclic- and cyclic butadiene systems, sandwich compound, synthesis and reactivity of ferrocene. Organometallic reagents, Preparation, structural and characteristic aspects: oxidative insertion, reductive elimination, ligand migration from metal to carbon. Organo lithium, organo copper compounds, organo boranes, organometallic compounds of Zinc, Cadmium, nickel, palladium, mercury and their utilization in chemical reactions. UNIT-IV Modern Synthetic Methods Reactions involving triple bond (Sonogashira reaction), C-C (Kumada, Negishi, Heck, Suzuki and Stille reactions) and C-N (Buchwald-Hartwig reaction) cross-coupling reaction. Protection and deprotection of functional groups (R-OH, R-CHO, RCO-R, $RNH_2$ and R-COOH).

**Module IV: Bio-Organic Chemistry**

Role of alkali and alkaline earth metal ions in biology; Na -K Pump, ionophores,And crown ethers. Metal site structure, function. Metal ion transport and storage: Ferritin, Transferrin, Siderophores and metallothionein. Electron Transfer: Cytochromes, Iron-Sulfur Proteins and Copper Proteins. Oxygen transport and storage: Hemoglobin, myoglobin, hemerythrin, hemocyanin Oxygen activation: Cytochrome P450, Cytochrome c oxidase. Other metal containing enzymes: Catalase, peroxidase, superoxide dismutase, alcohol dehydrogenase, carbonic anhydrase, carboxypeptidase, xanthine oxidase, nitrogenase, vitamin B12 coenzyme.

**Module V: Biomolecular catalysis**

Basic concepts of amino acids, peptides and proteins, structures of proteins, preliminary idea about enzyme, cofactor, co-enzyme, apoenzyme, prosthetic group, metal-activated enzyme and metalloenzyme. biological significance and mechanistic aspects of carboxypeptidase, carbonic anhydrase, blue-oxidases, non-blue oxidases, superoxide dismutase, structure and biological functions of molybdenum nitrogen.

# Paper: Advanced physics for nanotechnology (NSNT COR 203)

**Module I: Structure of Materials**
Introduction to Structure of atoms – Quantum states-Atomic bonding in solids-binding energy – interatomic spacing – variation in bonding characteristics – Single crystals – polycrystals– Non crystalline solids.

**Module II: Crystal Imperfections**
Imperfection in solids – Point and line defects-Frenkel defect –Schottky defect-Burger vectors-Vacancies – Interstitials – Geometry of dislocation –Schmid´s law – Surface imperfection – Importance of defects – Microscopic techniques – grain size distribution.

**Module III: Band Model of Semiconductors**
Carrier concentrations in intrinsic, extrinsic semiconductors – organic semiconductors – Fermi level – variation of conductivity, mobility with temperature – law of mass action – Hall effect – Hall coefficients for intrinsic and extrinsic semiconductors – Hall effect devices. Application of diffusion in sintering, doping of semiconductors and surface hardening of metals – influence of size on band gap energy.

**Module IV: Mechanical And Optical Properties**
Stress, Strain, Elastic properties – Deformation – elasticity – hardness – Optical properties – Light interaction with solids – Atomic, electronic interaction, non – radiative transition – refraction, reflection, absorption, transmission, luminescence.

**Module V: Magnetic Properties**
Dia and Para-magnetism–ferro, ferri and antiferromagnetism – magnetic hysteresis – Weiss molecular field theory - Heisenberg‘s theory – magnetic anisotropy – domain theory – Exchange length –nanomagnetism - superparamagnetism.

# Paper: Advanced biology for nanotechnology (NSNT COR 204)

**Module I: Principles of Drug Delivery Systems**
Modes of drug delivery, Absorption distribution metabolism excretion characteristics of drugs, Controlled drug delivery - site specific drugs, Barriers for drug targeting - passive and active targeting, Strategies for site specific drug delivery.

**Module II: Toxicity Assays and their Principles**
Cell viability, LDH release, ROS production, Morphological observation, Membrane potential, Live/Dead assay, Comet Assay, Cell cycle analysis and Apoptosis detection by flow cytometer.

**Module III: Nanoparticles and Cancer Therapy**
Cancer and its types: Mechanisms of progression in Cancer: Cellular trafficking, Cancer invasion, Migration, Angiogensis and Metastasis. Chemotherapy, Immunotherapy, Photodynamic Therapy (PDT), Photothermal Therapy (PTT), Magnetic Hyperthermia (MHT), High Intensity Focused Ultrasound (HIFU).

**Module IV: Targeted Drug Delivery**
Classification of targeted drug delivery systems, Bioconjugation, Nanoparticles surface modification - PEGylation, Gold nanoparticles for drug delivery, Magnetic nanoparticles as drug carriers.

**Module V: 3D Bio -Printing**
Introduction - History, principle and its components, Classification of 3D bio-printing techniques - Extrusion-based bio-printing, Droplet-based bio-printing, Laser-based bio-printing, Design Requirements for 3D Bio-printing- Magnetic Resonance Imaging, Computed Tomography, Computer-Aided Design Based Systems, 3D modelling softwares, Bio inks for 3D bio-printing - Applications of 3D Bio-printing and future trends.

## Paper: Open elective (NSNT DSE 205) *One elective from the following*

**E I: Nanocatalysis**

Introduction to Nanocatalysis. Definition and significance of nanocatalysis. Comparison of conventional catalysis and nanocatalysis. Advantages of using nanomaterials in catalysis (increased surface area, quantum effects, etc.). Types of Nanocatalysts: Metal Nanoparticles as Catalysts: Gold, silver, platinum, and other transition metal nanoparticles. Oxide Nanocatalysts: Titanium dioxide, zinc oxide, cerium oxide. Carbon-based Nanocatalysts: Carbon nanotubes, graphene, and fullerenes. Hybrid Nanocatalysts: Metal-organic frameworks (MOFs) and suported catalysis. Mechanisms in Nanocatalysis, Homogeneous vs. Heterogeneous Catalysis. Reaction Kinetics: Role of nanoscale catalysts in reaction kinetics. Catalyst Activation and Deactivation: Factors affecting catalyst performance at the nanoscale. Enzyme-mimetic Catalysis: Nanomaterials mimicking natural enzymes (nanozymes). Applications of Nanocatalysis Environmental Applications: Wastewater treatment, catalytic converters, photocatalysis for pollutant degradation. Energy Applications: Fuel cells, hydrogen production, solar cells, biofuels. Chemical Industry: Fine chemicals, petrochemical refining, green chemistry. Pharmaceuticals: Drug delivery systems, biocatalysis. Challenges and Future Directions in Nanocatalysis Stability and Reusability of nanocatalysts. Toxicity and Environmental Impact: Safety concerns related to nanomaterials. Scalability: Industrial production of nanocatalysts. Emerging Trends: Use of artificial intelligence and machine learning in designing nanocatalysts.

**E II: Molecular recognition & self-assembly**

Basic concept and principles; History, Molecular recognition, Hydrogen Bonds: Definition, Structure and Stability, strength, Secondary Electrostatic Interactions in Hydrogen Bonding Arrays. Non-covalent interactions: Ion pairing, Ion-Dipole Interactions, Dipole-Dipole interactions, Dipole-Induced Dipole and Ion-Induced Dipole interactions,van der Waals or Dispersion Interactions, Hydrogen bonding, Halogen bonding, Cation- interactions, Anion-pi interactions, pi - pi interactions, Closed shell interactions, Aromatic-Aromatic Interactions: Benzene Crystals, Edge-to-face vs. pi-pi Stacking Interactions, N-H- pi interactions, Sulfur-aromatic interactions, Benzene-Hexafluorobenzene pi-stacking. Biological supramolecular systems: Ionophores, Porphyrin and other Tetrapyrrolic Macrocycles, Coenzymes,

Neurotransmitters, DNA and Biochemical Self-assembly. Supramolecular reactivity Biomimetic systems and Artificial receptors: (a) Cation Binding Hosts - Podand, Crown Ether, Cryptand, Spherand; Nomenclature, Selectivity and Solution Behaviour; Alkalides, Electrides, Calixarenes and Siderophores. (b) Anion binding hosts - Challenges and Concepts, Biological Receptors, Conversion of Cation Hosts to Anion Hosts, Neutral Receptors, Metal-Containing Receptors, Cholapods. (c ) Ion Pair Receptors - Contact Ion Pairs, Cascade Complexes, Remote Anion and Cation Binding Sites, Symport and Metals Extraction.
(d) Hosts for Neutral Receptors -Clathrates, Inclusion Compounds, Zeolites, Intercalates, Coordination Polymers, Guest Binding by Cavitands and Cyclodextrins, cucurbituril. Transport processes; Dynamic Combinatorial chemistry

**E III: Drug delivery**

**Basics of Pharmaceutical Sciences:** Introduction to pharmaceutical sciences, principles and types of pharmaceutical dosage forms-solid, liquid, semi-solids, aerosols. Routes of drug administration, Basics of pharmacology overview, sources of drugs, routes of drug administration, Pharmacokinetics-absorption, distribution, metabolism and excretion, Pharmacodynamics, Adverse drug reactions, Drug interactions. Kinetics and Drug stability.
**Nanocarriers for drug and gene delivery:** Basics of drug delivery, Types-polymer, lipid, metal based drug delivery system and miscellaneous. Drug targeting strategies for site specific drug delivery-passive and active targeting, time and rate controlled drug delivery. Classification and types of polymeric nanocarriers, Different methods of polymeric nanocarrier preparation: Precipitation, Emulsion diffusion/Solvent evaporation, Salting out etc. Various applications of polymeric nanocarriers: Theranostic, Imaging etc. Introduction of different dendritic nanostructures, chemical structures, types of dendrimers, methods of preparation-convergent and divergent, physicochemical properties of dendrimers, interaction between drug molecules and dendrimers, applications of dendrimers. Challenges in gene delivery, basic concept, design of nanotechnology-based systems for gene delivery, Non-viral vectors, formulation strategies, applications in delivery of genes for different diseases.

## Paper: Open elective (NSNT DSE 206) *One elective from the following*

**E I: Instrumental techniques- data analysis**

**Spectroscopic techniques:** UV-vis, FTIR, Raman, NMR, EPR, Fluorescence, AAS, XRD, CD, Polarimetry
**Microscopic techniques:** Light, Fluorescence, Confocal, Electron, Force
**Mass spectroscopy:** HR-MS, LC-MS, GC-MS, ICP-MS
**Magnetic properties:** SQUID, VSM, PPMS
**Chromatography:** TLC, Column, Paper, GC, HPLC

**E II: Quantum mechanics**

Introduction to quantum mechanics: Planck and blackbody radiation, Einstein and specific heat and photo electric effect, Bohr model of H atom, Stern-Gerlach experiment, Compton effect, de Broglie hypothesis, Schrodinger equations. Some simple one particle applications of schrodinger's time independent equation: free particle, particle in a well, simple harmonic oscillator, rigid rotor, H atom. Many particle systems: approximation methods- variation, perturbation treatments. Elementary concepts of bonding: VB-MO theories, H2, homonuclear and heteronuclear diatomic molecules. Standard melthods for treating molecules- Hartree Fock and DFT theones, Outcome of such calculations. Large Systems: simulation methods, simple approximate methods (eg. molecular mechanics). A few case studies.

**E III: Informatics**

A word on informatics, Introduction, Branches. Aims of Bioinformatics, Scope/research areas of bioinformatics. Sequence and molecular file formats, Introduction, Sequence file formats, Sequenceconversion tools, Molecular file formats, Molecular file format conversion, Databases in bioinformatics & introduction: - Introduction, Biological databases, Classification schema of biological databases, Biological database retrieval system Biological sequence databases, National Centre for biotechnology information (NCBI), Introduction, Tools and databases of NCBI, Database retrieval tool, Sequence submission to NCBI, BLAST, PSI-BLAST, RPS-BLAST, Specialized tools, Nucleotide database, Literature database, Protein database, Gene expression database, GEO, Structural database, Chemical database, Other databases, EMBL Nucleotide Sequence Database, Introduction, Sequence retrieval, Sequence submission at EMBL, Resources of EMBL, Biological annotation and data curation, Sequence analysis tools, Features of database, DNA databank of Japan, Introduction, Resources of DDBJ, Data submission to DDBJ, Protein information resource, Introduction, Resources of PIR, Data retrieval of PIR, Databases of PIR, Swiss-Prot: Introduction, Features of Swiss-prot Protein 3D structure and classification databases, Protein databank, Introduction, Harnessing data from PDB, Data deposition tools, PDB beta, RCSB PDB structural genomics information portal, Molecular modelling databases, Introduction, Retrieval of structural data from MMDB, Conserved domain database, E-MSD, Introduction, Resources of E-MSD, Data submission at E-MSD, Search system of E-MSD, 3D genomics, Introduction, Assessing 3D genomics, Gene 3D, Introduction, Retrieving data from gene 3D, Protein structural classification Databases, Introduction, CATH Class, Architecture, Topology, Homologous, SCOP(Structural Classification of Proteins).

# Paper: Nanotechnology lab-I (NSNT COR 211)

1. Synthesis of nanoparticles (silver,gold) and analysis of localized surface plasmon resonance (LSPR).
2. Analysis of Temporal stability of nanoparticles.
3. Scanning electron microscopy and Energy dispersive X-ray spectroscopy (EDAX) of nanoparticles: Sample preparation and analysis
4. Dynamic light scattering study of nanoparticles: Sample preparation and analysis characterization.
5. Atomic force microscopy of nanoparticles: Sample preparation and analysis
6. Synthesis of super paramagnetic nanomaterials - iron oxide/ nickel oxide
7. Synthesis of semiconductor nanoparticles and characterization (CdS)

## Paper: Nanobiotechnology lab-I (NSNT COR 212)

1. Introduction to Microbial culture
2. Analysis of protein by SDS-PAGE
3. Western blotting and ELISA
4. Cellular uptake study of nanoparticles by confocal microscopy
5. Cell cycle analysis of nanoparticle-treated cells by flow cytometry
6. Isolation of DNA from different sources (Buccal swab, blood, animal & plant tissue)
7. Agarose gel electrophoresis
8. Quantitative & qualitative analysis of nucleic acid (NanoDrop, Qubit)
9. Polymerase chain reaction: general

## Paper: Computing lab-I (NSNT COR 213)

1. Data format (FASTQ, BED, GTF, GFF3, SAM, BAM and VCF);
2. Biological data base structure: NCBI, RCSB, KEGG

# Semester-III

## Paper: Nanotechnology for efficient energy devices (NSNT COR 301)

**Module I: Overview of Energy Challenges**
Global energy demand and challenges,The need for alternative energy source,Role of nanotechnology in addressing energy issues Nanomaterials for Energy Applications:Types of nanomaterials (nanoparticles, nanotubes, nanowires, quantum dots)Nanomaterials in energy conversion and storage.

**Module II: Nanostructured Solar Cells**
Introduction to photovoltaic (PV) systems,Types of solar cells: Silicon-based, Dye-sensitized Solar Cells (DSSC), Perovskite Solar Cells, Quantum dot Solar Cells.Role of nanomaterials in enhancing solar cell efficiencyNanotechnology in Light Absorption and Charge Transport:Nanoparticles for light trapping and absorption. Nanostructures in enhancing charge transport efficiency. Advanced materials like graphene and carbon nanotubes (CNTs) in solar cells.Hybrid and Thin-Film Solar Cells:Thin-film technologies and nanotechnology.Organic solar cells (organic photovoltaics, OPVs). Nanocomposite materials for hybrid solar cells.

**Module III: Nanotechnology in Batteries**
Lithium-ion batteries and their limitations
Role of nanomaterials in improving electrode performance (anode, cathode)Nanostructured electrodes for enhanced battery capacity and stability
Supercapacitors and Nanotechnology:Basic working principle of supercapacitors Use of nanomaterials (graphene, carbon nanotubes) in supercapacitors
Nanostructured materials for improved energy density and power performance
Hydrogen Storage and Fuel Cells:Nanotechnology in hydrogen production and storage
Nanomaterials for efficient hydrogen storage (metal-organic frameworks, nanoporous materials)
Nanotechnology in improving fuel cell efficiency (proton exchange membrane fuel cells).

**Module IV: Nanotechnology in Advanced Energy Systems**
Thermoelectric Energy Conversion:Basic principles of thermoelectric materials.Nanotechnology in enhancing thermoelectric efficiency.Nanostructured materials for efficient heat-to-electricity conversion.

**Module V: Nanomaterials in Catalysis for Energy Production**
Nanocatalysts for energy-efficient chemical reactions. Nanotechnology in bioenergy and biofuel production Role of nanostructured materials in improving catalytic activity.Emerging Nanotechnologies for Energy: Nanotechnology in next-generation batteries (solid-state, sodium-ion, etc.)Nanotechnology in energy-efficient lighting (LEDs, quantum dot-based lighting) Challenges and future trends I nanotechnology for energy devices

## Paper: Nanoelectronics (NSNT COR 302)

**Module I: Fundamentals of Nanoelectronics**
Introduction to Nanoelectronics: Definition and scope of nanoelectronics.Evolution from micro to nano-scale electronics Advantages of nanoelectronics over traditional electronics, Quantum electronics.

**Module II: Mechanics in Nanoelectronics**
Quantum confinement and tunneling effects, Density of states in nanostructures Schrodinger equation and wave-particle duality.Nanomaterials in Electronics:Types of nanomaterials (quantum dots, nanowires, carbon nanotubes, graphene) Synthesis and fabrication methods.Electrical, optical, and mechanical properties of nanomaterials.

**Module III: Nanoscale Devices and Fabrication Techniques**
Nanoscale Transistors: MOSFET scaling limits and short-channel effects FinFETs and other advanced transistor structures.Single-electron transistors (SETs) Fabrication Techniques: Top-down and bottom-up approaches Lithography techniques: Electron beam, nanoimprint, and soft lithography Self-assembly and molecular electronics Nanowires and Quantum Dots:Synthesis and applications of nanowires in electronics Quantum dot devices (QLEDs, QD memory devices)Applications of quantum dots in optoelectronics.

**Module IV: Emerging Nanoelectronic Devices**
Spintronics:Fundamentals of spintronics and spintronic materials.Spin valves, magnetic tunnel junctions, and GMR (Giant Magnetoresistance) devices.Applications in data storage and memory.MolecularElectronics:Introduction to molecular electronics and single-molecule transistors.Organic semiconductors and conductive polymersMolecular junctions and logic gates Nanoelectromechanical Systems (NEMS):Fundamentals of NEMS and comparison with MEMS Fabrication techniques for NEMS devicesApplications in sensors, actuators, and RF systems.

**Module V: Nanoelectronics in Energy**
Nanoelectronics in energy harvesting and storage devices.Nanoelectronics-based thermoelectric devices.Energy-efficient nanoelectronics for sustainable development.Challenges and Future.Directions:Scaling limits and heat dissipation issues.Challenges in commercialization and large-scale production. Future trends: Neuromorphic computing, flexible electronics, and 2D materials

# Paper: Nanotechnology in biology and healthcare (NSNT COR 303)

**Module I: Elements of Biomaterial Science**

Introduction of biomaterials science-Definition and classification of biomaterials-metals, ceramics, polymers and nanocomposites-Properties of biomaterials (Physical-Chemical-Biological-Mechanical-Electrochemical properties) - Nano-scale phenomena in biomaterials-Smart gels and their properties.

**Module II: Nanomedicines and Regenerative Medicine**
Concept of nanomedicines- Rationale for designing of nanomedicines-Nano-structures in nanomedicines-transport of nanoparticles across the biological barriers, parameters affecting

binding and uptake of nanoparticles-size, shape, surface charge, protein corona, surface modification-Clinical translation of nanomedicines: Preclinical and clinical considerations of nanomedicines-Regulation of nanomedicines. Introduction to regenerative medicine-Methods of cell based therapy-Stem cells-Molecular and cellular based of organ development-Therapeutic uses of stem cells-Molecular bases of disease- Bio-artificial organs; Artificial pancreas-Lever-Ear-Heart-Ethics-Current issues in patent law- From concept to market (Regenerative products).

**Module III: Nanosensors**

Active and passive sensors - static characteristic - accuracy, error, precision, resolution, sensitivity, selectivity, noise, drift, detection limit - reproducibility, hysteresis, stability, response time, recovery time, dynamic range - dynamic characteristics - zero order, first and second order sensors. Photoelectric effect - photo dielectric effect - photoluminescence effect – electroluminescence effect - chemiluminescence effect - Barkhausen effect - Hal effect - Ettinshausen effect - thermoelectric effect - peizoresistive effect – piezoelectric effect - pyroelectric effect - Magneto-mechanical effect (magnetostriction) - Magneto resistive effect. Physical sensor, Chemosensor and Biosensor. Biosensor: Nanoparticle-Based Electrochemical Biosensors –DNA enabled biosensors - CNT-Based Electrochemical Biosensors - Functionalization of CNTs for Biosensor Fabrication Quantum Dot-Based Electrochemical Biosensors - Nanotube- and Nanowire-Based FET Nanobiosensors - Cantilever-Based Nanobiosensors - Optical Nanobiosensors.

IoT Based Sensors: Internet of things – Building blocks of IoT, Characteristics of IoT- Design of IoT – connectivity – mobile-satellite-Bluetooth -Wi-Fi – Wimax- IoT enabled technologies – IoT communication models -Internet of nano things - sensor network – Applications – Agriculture – Transport –Environment – Health care – wearable devices.

**Module IV: Nanoparticles and Cancer Therapy**

Introduction and Rationale for Nanotechnology in Cancer Therapy - Passive Targeting of Solid Tumors: Pathophysiological Principles and Physicochemical Aspects of Delivery Systems-Active Targeting Strategies in Cancer with a Focus on\Potential Nanotechnology Applications - Pharmacokinetics of Nanocarrier-Mediated Drug and Gene Delivery – Multifunctional Nanoparticles for Cancer Therapy- Neutron Capture Therapy of Cancer: Nanoparticlesand High Molecular Weight Boron Delivery Agents. Nano-Oncology- NanoneurologyNanocardiology-Nano-Orthopedics- Nano-Ophthalmology Nanobiomolecules crossing blood brain barrier, bioconjugation and biocompatibility. Tissue engineering: Biomemetics design, Nanobiomechanics of living cells, Multi-functional nanozymes, Polymeric scaffolds, Nanoengineered hydrogels, cell repair machines, Fundamentals of Drug and gene delivery, gene alteration, cell interactions, Stem cell treatment, Biopharmaceuticals, medical implications. Biochips, Micro arrays, BioMEMs, Molecular Imaging, Cancer therapy using nanomedicine-Use of nanotubes, quantum dots, polymeric conjugates, Dendritic nanostructures, Fe/Au Nanoshell for tumor targeted imaging, delivery and therapy, Use of multifunctional nanoparticles in chemotherapy, Molecular nanosubmarines, Photoablation and hyperthermia, Nanoencapsulation technologies.

**Module V: Biomimetics and bionics**

Biomimetics- Introduction, Confluence of Nanotechnology and Biomimetics, Mimicking biological structures using inorganic materials- Gecko Tape, Bone Tissue Regeneration and

Artificial Photosynthesis.Utilizing nature on the molecular scale- Biological Self Assembly, Viral Construction, Protein Motors. Principle of biological materials as protein based robust materials- collagens, keratins, spider webs, silks, bio- adhesives. Principle of biological materials as hierarchal nanostructures- bones, sea shells, diatoms, sponges. Principle of biological materials in optical applications- butterfly wings and insect eyes. Design principle to develop novel functional materials and devices. History and Introduction to Bionics, Challenges and future of Bionic Technology.Applications of Bionics in engineering- Sonar, Radar and Medical Ultrasound; in Computer Science- Artificial Neural Networks and Swarm Intelligence.in medicines- Myoelectric control. History and Introduction; Applications of DNA Nanotechnology: DNA based artificial membrane channel, membrane floating proteins, artificial organelles, artificial cells. Biomimetic fabrication of DNA based metallic Nanowires and Networks. Future prospects.

## Paper: Environmental and Societal impact of nanotechnology (NSNT COR 304)

**Module I: Introduction to Nanotechnology and Its Applications**

Basics of Nanotechnology Introduction to Nanoparticles, Nanotubes, and Nanocomposites Medicine: Targeted Drug Delivery and Diagnostics. Electronics: Nanoscale Transistors and Quantum Dots. Energy: Nanotechnology in Solar Cells and Batteries.Environment: Water Purification and Pollution Control.Assignment: Research and report on a recent advancement in nanotechnology.

**Module II: Environmental Impact of Nanotechnology**

Positive Environmental Contributions**.** Nanotechnology in Pollution Prevention and cleanup**.** Nanomaterials in Renewable Energy and Energy Efficiency**.** Agriculture: Nano-enhanced Fertilizers and Pesticides**.**Environmental Risks and Challenges**.**Toxicity of Nanoparticles: Effect on Aquatic Life and Microorganisms**.**Nanoparticle Waste and Environmental Accumulation**.**Case Studies: Environmental Disasters Linked to Nanoparticles**.**

**Module III: Healthcare and Medicine**

Nanomedicine: Targeted Drug Delivery and Disease Detection. Ethical Issues in Nanomedicine: Privacy and Accessibility Concerns. Case Studies: Nano-drug treatments in cancer and other diseases

**Module IV: Environmental Remediation through nanoparticles**

Nano Membranes, Nano Meshes, Nano Fibres,Nano Clays and Adsorbents, Zeolites, Nano Catalysts, Carbon Nano Tubes. Nanotechnology.For waste reduction and improved energy efficiency, nanotechnology based water treatment strategies.Nanoporous polymers and their applications in water purification. Environmental Pollution by Nanoparticles: Health impact, safety and toxicological effects transport of nanomaterials inSoil/sediments. Study of physical and chemical properties of nanomaterials influencing their behavior.

**Module V: Nanotechnology in Agriculture**

Precision farming, Smart delivery system–Nanofertilizers:.anourea and mixed fertilizers, Nanopesticides, Nanoseed Science. Nanotechnology in Food industry.Nanopackaging for enhanced shelf life – Smart/Intelligent packaging – Food processing and food. Safety and bio-security – Electrochemical sensors for food analysis and contaminant detection.

# Paper: Research methodology and IPR (NSNT SEC 305)

**Module I: Research methodology**

Research objective and statement of problem, types of research; Research proposal designing and formulation; Research Methodology; Review of literature, meaning of concept, construct, laws, theory and hypothesis. Writing of Research Proposal, Report and Research Paper: Meaning and types -Stages in preparation - Characteristics - Structure - Footnotes and Bibliography - use of Endnote. Checklist for a good proposal/ report/ research paper.

**Module II: Impact of research**

Concept of impact factor, i-10 index, H-index; Methods of the best journal selection; checklist for avoiding predatory/fake journals; steps for publishing an article in a peer-reviewed journal.

**Module III: Bioethics**

Introduction to ethics and bioethics, the responsible conduct of biotechnological research; research with human subjects; social commitment of a biotechnologist; Ethical legal and social issues (ELSI) in biotechnology: Biotechnology/ biomedicine application - ethical consideration; ethics and the natural world: environmental ethics (protecting public health and environment; genetically modified foods – the ethical and social issues. ELSI in genetic engineering/biomedical science, Eugenics, Use and Misuse of genetic information, Human gene patenting – ethics and policy issues, genetic testing and screening, human gene therapy and genetic modification – ethical and public consideration, legal implication of somatic cell, gene therapy- germ line gene therapy.

**Module IV: IPR**

IPR: Jurisprudential definition and concept of property rights, duties and their correlations, history and evaluation of IPR – like patent design and copyright. Distinction among the various forms of IPR, requirements of a patentable invention like novelty, inventive step and prior art and state of the art procedure; Rights/ protection, infringement or violation, remedies against infringement, civil and criminal, Indian patent act 1970 (2000) international convention in IPR, major changes in Indian patent system as post TRIPS-GATT-International conventions effects. Contents of patent specification and procedure for patents: a) obtaining patents, b) geographical indication c) WTO. Detailed information on patenting biological products, Biodiversity and farmer rights, Budapest treaty, Case studies on - Patents (basmati rice, turmeric, neem, etc.)

**Module V: Entrepreneurship**

Entrepreneur & Entrepreneurship concept: role of entrepreneurship in economic development; factors affecting entrepreneurial growth; developing and evaluating opportunities; Growing & sustaining enterprise: Developing start-up strategies, measuring market opportunities. Role of knowledge centres: Knowledge centres like Universities & research Institution, Role of

technology & up-gradation, managing technology transfer, regulations for transfer of foreign technologies, support mechanism for entrepreneurship in India.

# Paper: Chemi-informatics and Bioinformatics (NSNT SEC 306)

**Module I: Chemi-informatics**

Basics of Cheminformatics. Medicinal Chemistry. Modern Combinatorial Chemistry. Chemical Database Design and Their Management. Chemical Information Sources. Computational Chemistry. Data Sequencing Mining and Visualization.

**Module II: Bioinformatics**

Genomics: Structural and Functional Genomics, Sequence based approach, EST and dbEST, SAGE analysis Microarray based approach, Software: Arrayplot, SNOMAD, Mutational genomics, Comparative genomics, Organization of Genome, Strategies of Genome Sequencing, Model Plant Genome Project, Functional Analysis of Genes. Proteomics Data and Databases; UniProtKB, IntAct, Reactome, PRIDE, peptides Atlas,Software and open source tools; Reusing shared data, Application, challenges and opportunities of proteomics, Human Proteome Project; The human protein atlas.

**Module III: Biomarker**

Protein identification and quantification; PeptideShaker; Post processing of proteomics data; Post-translational modifications identification; Biomarker candidate identification.

**Module IV: Drug Design and Discovery**

Introduction. Lead compound concept: identification and modification. Molecular modification. Recptor and drug targets: Membrane protein, DNA, RNA, anzyme. Modeling of drug. Principles. Effectors of drug design. Fragment based drug design. Combinatorial chemistry. Computer aided drug design.

**Module V: Vaccine design**

Computational Immunology: MHC peptides –Structure and interactions, QSAR based predictions of epitopes.Principles of B-cell and T-cell epitope prediction, epitope mapping tools, Epitope modification, Allergenicity prediction. Vaccine design and system immunology, Reverse vaccinology.

# Paper: Nanotechnology lab-II (NSNT COR 311)

1. Removal of pollutants and heavy metals from water
2. Observing Rabi splitting through absorption study of interaction between different metal nanoparticles and several cyanine dye J-aggregates.
3. Photocatalytic activity of nanomaterials.
4. Thin film preparation by spin coating technique
5. Biogenic synthesis of silver/gold nanoparticles
5. Synthesis of carbon nanotubes/ nanofibers.

## Paper: Nanobiotechnology lab-II (NSNT COR 312)

1. Animal cell culture/plant tissue culture
2. Treatment of animal cell with Nanoparticle
3. Toxicity assay
4. Confocal microscopy
5. SEM of biological sample

## Paper: Computing lab-II (NSNT COR 313)

1. Primer design
2. Network biology-PPI
3. Pathway analysis: STRING, Reactome, Cytoscape

# Semester-IV

## Paper: Project/Dissertation and presentation (NSNT COR 401)

## Paper: Review writing and presentation (NSNT COR 402)

## Paper: Grand viva (NSNT COR 403)