Institute of Nano Medical Sciences (INMS)
University Of Delhi

Ordinance relating to M.Sc. (Master of Science) in Nanomedical Sciences

M.Sc. (Master of Science) course in Nanomedical Sciences

1. There shall be a course leading to Master of Science (M.Sc) degree in Nanomedical science at Institute of Nano Medical Sciences, University of Delhi in each of the following subject specializations, under the Faculty of Medical Sciences.

a) Cancer Nanomedicine
b) Nano Pharmaceutical Chemistry
c) Clinical trials and Translational nanomedicine
d) Nano-vaccine
e) Nano medicine in Regenerative medicine
f) Nano Biosensors

2. The duration of the course shall be two academic years.

3. A candidate seeking admission to M.Sc. in Nano Medical Sciences course must have passed the Bachelor of Sciences examination in Life Science/ Zoology/ Botany/ Microbiology/ Chemistry/ Environmental Biology / Biotechnology / Lab techniques/ B. tech / Bioinformatics/ M.B.B.S / B. Pharma / B.D.S. /B.A.M. S/ B.V.Sc. and engineering sciences etc. with at least 55% marks or 6.0 CGPA from university of Delhi or any other examination recognised by the University as equivalent thereto, and also must possess such other qualifications Including passing of an entrance examination written and or practical, and /or oral, as may be prescribed by the Academic Council from time to time.

4. There shall be an examination at the end of each semester, Part-I and Part-Il examinations in the first year; 2nd Part-Ill and Part-IV examinations at the end of each semester in the second year.

The examination in the Part-IV shall consist of a thesis and viva-voce or a written examination (in lieu of thesis), (see Annexure I).

5. A candidate registered for the course shall not be deemed to have satisfied the required condition of the attendance unless he/she has attended not less than 75% of the lectures and the practicals separately in each subject in order to be eligible for admission to each examination (Part-I, Part-Il, Part-III)

No candidate shall be allowed to appear at the Part-IV (fourth semester) examination unless the supervisor (s) guiding the candidate for the thesis work has reported that he/she is satisfied during the semester year, such a report from the supervisor shall be subject to the satisfaction of the Director of the INMS.

6. Scheme of Examination

Part-I (First Semester)

The Part-I shall consist of the following papers and will be common for all the branches of the M.Sc in Nano Medical Sciences degree courses and shall consist of :

Semester I:

S. No.	Paper name	Paper topic	Credits
1	Core 1	Biomolecules and Biomacromolecules for Nanomedicine	4
2	Core 2	Introduction to Nanomaterials: Types and Synthesis	4
3	Core 3	Basic properties and Characterization of Nanopartilces	4
4	Practical 1	A) Basic nanoparticle synthesis B) Characterization studies of nanoparticles	4

Total Credit: 16

Part-II and Part-III. (Second and Third Semester)

The Part-II and Part-III shall consist of special papers (elective/open Elective). A student is required to take total of 16 credits (atleast nine per semester). He/She may choose any of the special papers offered by the department during the period. A list of different special courses is given below. At the end of each semester there will be a three hours exam for each course.

Core Courses (minimum of 16 credits). Students must consult their advisors when selecting courses, because of the composition of the comprehensive examination for each speciality area.

Semester II:

S. No.	Paper name	Paper topic	Credits
1	Core 4	Basics of cell biology and organ system	4
2.	Core 5	Nanomaterials for Diagnostics and therapeutic applications	4
3	Core 6	Interaction of nanomaterials with biological system	4
4	Practical 2	A)Basic nanoparticle interactions-Imaging B) *in vitro* studies using nanoparticles	4

Total Credit: 16 + Elective 4 + Open Elective 2 = 22

S. No.	Paper name	Paper topic	Credits
1	Elective 1*	Nanomaterials for antimicrobial applications	4
2	Elective 2*	Nanomaterials in regenerative medicine	4
3	Elective 3*	Pharmacokinetics and Pharmacodynamics	4
4.	Elective 4*	Nanobiosafety and nanotoxicology	4

Total Credit: 16 + Elective 4 + Open Elective 2 = 22

Semester III:

S. No.	Paper name	Paper topic	Credits
1	Elective 1*	Nanomaterials for antimicrobial applications	4
2	Elective 2*	Immune System and Innate Immunity	4
3	Elective 3*	Pharmacokinetics and Pharmacodynamics	4
4	Elective 4*	Nanobiosafety and Nanotoxicology	4
5	Elective 5*	Recombinant DNA technology and non-viral gene therapy	4
6.	Elective 6*	Cancer nanomedicine	4
6	Open elective 1	Ethics in Research: Responsibilities to Society, Science, and Self	2
5	Practical 3	Immunotechniques, Biotechniques, *in vivo* studies using nanoparticles	

* Any two

7. Part IV Thesis (Specialization/ Thesis)

After passing the examination in the theory papers (Part-I, Part-Il and Part-III), a student shall be required to write a dissertation on a subject approved by the advisory committee under the supervisor/ s appointed for the purpose or can take special courses for eight credits (sec Annexure I). Only candidates who have passes at Ieast 50 credits (our of 60 credits) of courses written and practical taken together as in the case of other post-graduate science Course shall be permitted to pursue the Part-IV (fourth semester) of the course.

The Examination in Part-IV shall consist of a thesis and viva-voce.

	Semester IV		4
1	Open Elective 2	IPR aspects, clinical trials and translational nanomedicine	2
2	Project work	Six months Thesis 16 Viva voce 4	20

Thesis

The subject of the thesis shall be approved on the recommendations of the Supervisors and the Director of the Institute by the committee of Courses in Nanomedical Sciences.

A candidate shall not be entitled to submit the thesis unless he/she pursued his/her research for a period of not less than one semester under the guidance of the Supervisor/s appointed by the Committee of courses and studies in Nanomedical Sciences, provided further that the Committee may appoint more than one Supervisor in any particular case. The dissertation will be submitted only when the Supervisor/ s concerned is/are satisfied that the dissertation is worthy of consideration in part-fulfilment of the M.Sc. Degree, provided that the application for submission of dissertation shall also be countersigned by the Director of the Institute in which the project was undertaken. The dissertation may include result of original research, a fresh interpretation of existing facts and data, or a review article of a critical nature, or may take such other form as may be determined by the advisory committee.

8. Every candidate shall submit one printed and three soft copies in CD of his/her thesis by March 31st every year duly signed by the supervisor/ s. Under very special circumstances the last date for submission of the thesis may be extended by one month with the permission of the Director of the Institute of Nano Medical Sciences. On receipt of thesis the University shall appoint two experts to examine the thesis and conduct the viva-voce.

The thesis shall embody the result of applicant's original research. The candidate shall indicate in their thesis in what respect their contribution appears to them in the advancement of the knowledge of the subject.

9. The Examiner shall assess the thesis and award marks for the thesis and the viva-voce jointly.

In case the candidate fails to secure the minimum pass marks on the combined performance of the thesis and the viva-voce he/she may revise the thesis in the light of suggestions of the Examiners or submit a fresh thesis on his/her being enrolled as an ex-student in relation to the next semester's Examinations. A resubmitted thesis will be examined by the same Examiners unless they are unable or un-willing to act as Examiners. Re-submission of the thesis shall be permitted after the candidate has put in at least three months of research work and resubmit the same within six months from the date of publication of the results in the first instance and after at least one year or the research work when the thesis is rejected subsequently.

10. A candidate admitted to the M.Sc. (Nanomedical Science) Course should pass the Examination within four years from the date of admission.

11. Results:

Part-I, II, III: - A candidate must have obtained at least 50% marks in each of the theory papers and practical separately in order to be declared to have passed each semester of the Examinations.

Part-IV: - A candidate must have obtained at least 50% marks in the thesis and viva-voce (combined) to be declared to have passed the Part IV of the Examination.

12. Classification of Result

At the end of the second year, the successful candidates shall be classified as follows:

First Division - 60 credits or more marks in the aggregate of all the examinations.
Second Division - 50 credits or more marks in the aggregate of all the examinations.
Third Division - 40 credits or more marks in the aggregate of all the examinations.

OR

A^+	(Outstanding)	75 and above
A	(I Division)	60 to 74.99
B^+	(II Division)	50 to 59.99
B	(III Division)	40 to 49.99
C	(Fail) Below	40

13. **Examination Fee** (As per University rules and already approved for the Faculty of Management Studies)

14. **Remuneration to Examiners:** (As per University rules)

15. Subject to the statutes and ordinances of the University each M.Sc. (Nano Medical Science) student shall remain under the control and discipline of the Director of the Institute of Nano Medical and other partner institutions imparting the course.

Annexure I

MSc Nano Medical Sciences

Duration 2 years

Semester I:

S. No.	Paper name	Paper topic	Credits
1	Core 1	Biomolecules and Biomacromolecules for Nanomedicine	4
2	Core 2	Introduction to Nanomaterials: Types and Synthesis	4
3	Core 3	Basic properties and Characterization of Nanopartilces	4
4	Practical 1	C) Basic nanoparticle synthesis D) Characterization studies of nanoparticles	4

Total Credit: 16

Semester II:

S. No.	Paper name	Paper topic	Credits
1	Core 4	Basics of cell biology and organ system	4
2.	Core 5	Nanomaterials for Diagnostics and therapeutic applications	4
3	Core 6	Interaction of nanomaterials with biological system	4
4	Practical 2	A)Basic nanoparticle interactions-Imaging B) *in vitro* studies using nanoparticles	4

Total Credit: 16 + Elective 4 + Open Elective 2 = 22

S. No.	Paper name	Paper topic	Credits
1	Elective 1*	Nanomaterials for antimicrobial applications	4
2	Elective 2*	Nanomaterials in regenerative medicine	4
3	Elective 3*	Pharmacokinetics and Pharmacodynamics	4
4.	Elective 4*	Nanobiosafety and nanotoxicology	4

Total Credit: 16 + Elective 4 + Open Elective 2 = 22

Semester III:

S. No.	Paper name	Paper topic	Credits
1	Elective 1*	Nanomaterials for antimicrobial applications	4
2	Elective 2*	Immune System and Innate Immunity	4
3	Elective 3*	Pharmacokinetics and Pharmacodynamics	4
4	Elective 4*	Nanobiosafety and Nanotoxicology	4
5	Elective 5*	Recombinant DNA technology and non-viral gene therapy	4
6.	Elective 6*	Cancer nanomedicine	4
6	Open elective 1	Ethics in Research: Responsibilities to Society, Science, and Self	2
5	Practical 3	Immunotechniques, Biotechniques, *in vivo* studies using nanoparticles	

* Any two

Semester IV:

S. No.	**Paper name**	**Paper topic**	**Credits**
1	Elective 7*	Biosensors	4
2	Elective 8*	Nanomedicine for neurological diseases	4
3	Elective 9*	Nanomedicine for pulmonary, hepatic and nephrological diseases	4
4	Elective 10*	Nanomaterials in regenerative medicine	4
5.	Elective 11*	Nanovaccines	4
6.	Elective 12*	Industrial Pharmacy	4
	Practical	Synthesis of micropartcles for vaccines, Immune responses in *in vivo* studies	4
	Semester IV		4
4	Open Elective 2	IPR aspects, clinical trials and translational nanomedicine	2
5	Project work	Six months	20

* Any two

Annexure -II

Core 1: Biomolecules and Bio-macromolecules for Nanomedicine

Duration: 60 hrs

Unit I: Nature, Properties and Function of Carbohydrates: Sugars-dissacharides, trioses, tetroses, pentoses, hexoses – stereoisomers – amino sugars, phosphosugars, sugar derivatives, deoxysugars - Oligossacharides-polyssacharides - homo and hetero polyssacharides, amylose, amylopectin, dextrans, limit dextran – starch - glycogensynthesis and degradation-glycolysis, TCA cycle, glycosyl moieties, cell wall polyssacharides – cellulose, chitin.

Unit II: Nature, Properties and Function of Lipids: Fats, Oils, Waxes; Fatty acids:
types, saturated, unsaturated, essential, short and long chain; triglycerides, lipids and cholesterol; Biosynthesis of fatty acid/triglyceride/cholesterol and Biological oxidation/degradation of alpha, beta and omega fatty acids.

Unit III: Nature, Properties and Function of Proteins: Amino acids: Essential and non-essential amino acids, dipeptides, oligipeptides, polypeptides. monomers, dimers, oligomers; fibrous proteins and globulins; primary, secondary, tertiary, quarternary structures; disulfides, hydrogen bonds, Schiff's base- amino and carboxy termini - alpha helix and beta plates; triple helix; Ramachandran plots.

Unit IV: Nature, Properties and Function of Nucleic acids: Nitrogen bases-purines, pyrimidines, nucleosides and nucleotides-oligonucleotides - base paring- DNA, RNA-tRnNA, mRNA, rRNA, antisense RNA-linear and circular forms, single and double stranded; hypo and hyperchromicity-extra chromosomal DNA- mitochondrial, choloroplastic, plasmid and viral – microsatellites – DNA varieties – A, B, and Z – Okazaki fragment – palindrome-concatenation- polymorphism – mutation – strand breaks – genes – promoters, enhancers, structural genes - gene expression – gene silencing - transposons – telomeres.

Core 2: Introduction to Nanomaterials: Types and Synthesis

Duration: 60 hrs

Unit I: Types of nanomaterials: polymeric, Liposomes, Micelles, lipid-based, hydrogels, metal-based, semiconductor-based, hybrid, Dendrimers, Quantum dots etc.

Unit II: Nanomaterial synthesis: Microemulsion, templated synthesis, hot colloidal method, sol-gel method, co-precipitation methods, etc. Phase-transfer and surface coating/bioconjugation. Basic characterization using electron microscopy, IR and optical spectroscopy, elemental analysis, x-ray diffraction, etc.

Unit III: Properties of nanomaterials in Medicine, Properties of Materials: Bulk Properties of Materials, Surface Properties of Materials. Classes of Materials Used in Medicine: Structure and Properties of Metals, Ceramics, Glasses, and Glass-Ceramics, Polymers, Hydrogels, Family of Carbon Nanomaterials, Bioresorbable and Bioerodible Materials, Composites, Thin Films, Grafts and Coatings, Biologically Functional Materials.

Unit IV: Materials classification by bonding, amorphous and crystalline materials, crystal lattices, Miller Indices, Bragg's Law, Defects in crystal structure, principles of dislocations, theory of diffusion, mechanical properties, phase diagrams, polymeric materials, composite materials, corrosion, electrical and optical properties, types of nanomaterials, surfaces and particle size, surface energy and surface tension and relation to size, phase transformations in nanomaterials, specific heat and heat capacity of nanomaterials, mechanical properties of nanomaterials, optical properties of nanomaterials, electrical and magnetic properties of nanomaterials, carbon-based nanomatertials.

Core 3: Basic properties and Characterization of Nanoparticles

Duration: 60 hrs

Unit I: State of the art techniques for measuring nanoparticle size distribution Basics of transmission and scanning electron microscopy, instrumentation, sample preparation, negative staining, data analysis and interpretation, selected area electron diffraction (SAED).

Unit II: Characterization techniques of nanomaterials: Basic principles of dynamic light scattering (DLS), diffusion coefficients, size determination using Stokes-Einstein equation. X-ray diffraction techniques, Bragg's law, Miller indices, Scherrer equation. UV-visible-NIR absorbance, fluorescence, and photoluminescence (PL) spectroscopies, Lambert Beer's law, quenching of fluorescence, Stern-Volmer's equation, fluorescence resonance energy transfer (FRET).

Unit III: Basics of functional group analysis: using IR, FTIR and NMR spectroscopies. Elemental analysis using Energy dispersive X-ray (EDX) and x-ray photoelectron (XPS) spectroscopies. Analysis of magnetic properties using vibrating-sample magnetometer (VSM) or superconducting quantum interference device (SQUID) magnetometer.

Unit IV: Surface and porosity analysis using BET technique. BJH isotherm for pore-size analysis; Basics of DTA, TGA, and DSC techniques.

Core 4: Basics of cell biology and organ system

Duration: 60 hrs

Section A: Biology of Cell and Cell Function:

Unit I: Cell as unit of life. Prokaryotes and Eukaryotes cells- Structure and functions. Ultrastructure of plant, animal and microbial cells. Types of cells: Glial, Astrocytes, Oligodendroglia, Fibroblasts;

Unit II: Cell cycle and regulation: The cell cycle and its control system, Interphase, Mitosis, Cytokinesis and molecular regulation, cell transformation, cell death and apoptosis. Unit **Intercellular communication**: Transport mechanisms across membrane, Cell signaling, Cell junctions, Cell adhesion and the extracellular matrix, Specialized cells, tissues, **Cell proliferation and differentiation**: pluripotency, totipotency, progenitor cells, differentiated cells; Membrane transport, nuclear transport, transcription, translation; Cell communication and Cell signalling-hormones, cytokines-natural products.

Section B: Human Physiology and Pathophysiology

Unit III: Introduces major topics in human physiology, emphasizing knowledge essential to health-related laboratory research. Topics include neurophysiology, immunology, cardiovascular, respiratory, renal, and gastrointestinal physiology and endocrinology.

Unit IV: Systems Physiology: General introduction to systems physiology. Homeostasis, function, and common pathological conditions in various human organ systems including: Cardiovascular and circulatory system, nervous system, renal system, gastrointestinal and hepatobiliary system, reproductive system, skin, pulmonary system, vision and auditory systems, ear, nose and throat, and the musculoskeletal system.

Core 5: Nanomaterials for diagnostics and therapeutics

Duration: 60 hrs

Section A: Diagnostics

Unit I: Application of core or probe-loaded nanoparticles in plasmonic, optical Imaging applications. Plasmonic nanoparticles and surface plasmon resonance (SPR) imaging, Fluorophore-loaded nanoparticles in advanced optical imaging.

Unit II: Cell Imaging, Multimodal bioimaging using nanoparticles. *In vitro* diagnostics and high throughput screening of disease biomarkers from body fluids. Nanomaterials in microfluidics.

Unit III: Magnetic nanoparticles in MRI imaging. Doping of diagnostic probes (e.g. gadolinium ions) with nanomaterials. Unique effects of drug interaction with nanomaterials: e.g. aggregation-enhanced emission.

Unit IV: Radio diagnostics: Radiochemistry and Radio Pharmacy; Introduction to Nuclear Medicine; Nanoparticles for PET and SPECT imaging; X-ray activated radiation diagnostics, CT imaging.

Section B: Therapeutics

Unit I: Drug encapsulation: Entrapment Efficiency, Loading Efficiency, surface conjugation (covalent *versus* non-covalent). Hydrophilic *versus* lipophilic drugs. Loading, retention and release studies. Enzyme-entrapment within nanomaterials. Fabrication of multifunctional nanoparticles. Stimuli-sensitive nanoparticles; Externally activated therapies such as photodynamic therapy (PDT), photothermal therapy (PTT) and magnetic hyperthermia therapy (MHT).

Unit II: Drug Delivery: Active *vs* passive, Controlled, Sustained and targeted drug delivery. Inorganic Nanoparticles; Lipid Nanoparticles; Peptide/DNA Coupled Nanoparticles for Drug Delivery; Metal/Metal Oxide Nanoparticles (antibacterial/anti-fungal/anti-viral); Anisotropic and Magnetic Particles (Hyperthermia). Interaction of nanomaterials with active agents such as drugs, photosensitizers and genes.

Unit III: Nuclear therapy: Nanoparticles loaded with radioisotopes (e.g. alpha or beta emitters); X-ray activated radiation therapy, Particle therapy involving interaction of ion beams with nanoparticles. Image-guided therapeutics and theranostic applications involving nanoparticles.

Core 6: Interaction of nanomaterials with biological system

Duration: 60 hrs

Unit I: Biophysicochemical influences on the interface between nanomaterials and biological systems: Size, shape, surface area, Surface charge, energy, roughness and porosity, Valence and conductance states. Functional groups, Ligands, Crystallinity and defects; Hydrophobicity and hydrophilicity.

Unit II: Suspending media: Water molecules; Acids and bases; Salts and multivalent ions Natural organic matter (humics, proteins, lipids) Surfactants; Polymers; Polyelectrolytes; **solid–liquid interface**: Surface hydration and dehydration; Surface reconstruction and release of free surface energy; Ion adsorption and charge neutralization; Electrical double-layer formation, zeta potential, isoelectric point; Sorption of stearic molecules and toxins; Electrostatic, stearic and electrostearic interactions Aggregation, dispersion and dissolution;

Unit III: Probing nano-bio interface interactions between NPs and cell membrane: specific and nonspecific forces; Receptor–ligand binding interactions Membrane wrapping: resistive and promotive forces; Biomolecule interactions (lipids, proteins, DNA) leading to structural and functional effects; Free energy transfer to biomolecules; Conformational change in biomolecules; Oxidant injury to biomolecules; Mitochondrial and lysosomal damage, decrease in ATP.

Unit IV: Routes of cellular entry: Protein corona; endocytosis, pinocytosis, phagocytosis, etc. Intracellular distribution and accumulation of nanoparticles.

Discipline Specific Electives

Elective 1: Nanomaterials for antimicrobial applications

Duration: 60 hrs

Interaction of nanomaterials with bacterial, viral, fungal strains. Antibacterial function of metal nanoparticles. Amphotericin-B loaded nanoparticles for treating fungal infections. Drug and gene-loaded nanoparticles for treating viral diseases. Light and magnetic-field activated nanoparticles for hyperthermia-based microbial decontamination. Nanoparticle-based bandages for treating infected wounds. Analysis of pre-clinical evaluation of antimicrobial effects of nanoparticles.

Elective 2: Immune System & Innate Immunity

Duration: 60 hrs

Unit I: Introduction to the Immune System & Innate Immunity: Primary and secondary lymphoid organs; Cells of the immune system; Innate Immunity as first line of host defense, distinction between self and non-self, complement system- classical and alternative, Types of innate immune cells and their functions in immune responses, Molecules of innate cells, Response of the innate immune systems to pathogens.

Unit II: Molecules & Cells of the Adaptive Immune System: Antigens: chemical and molecular nature, adjuvants and their functions; Recognition of antigen by B-cell and T-cell Receptors; Generation of lymphocyte antigen receptors (antibodies and TCR), Antigen presentation by Major histocompatibility complex molecules. Antigen receptor structure and signaling pathways, Generation of lymphocytes in bone marrow and thymus, Survival and maturation of lymphocytes in peripheral lymphoid tissues.Adaptive Immune Response: T Cell-Mediated Immunity, the production of armed effector T cells, General properties of armed effector T cells, T cell-mediated cytotoxicity; Humoral immune response, B-cell activation by armed helper T cells, Adaptive immunity to infection, Infectious agents and how they cause disease, The course of the adaptive response to infection, mucosal immune system, Immunological memory

Unit III: Immune System in Health and Disease: Pathogen response to immune system, Immunodeficiency diseases, Allergy and hypersensitivity; Autoimmunity and transplantation; Disorders of immune response: IBD and MS: a case study; Cancer immunology.

Unit IV: Immunotechniques: Principles of immunization, techniques for analysis of immune response, antibody related techniques; Hybridoma, epitope mapping; Immuno assays: RIA, ELISA, Immunoblotting, ELISPOT,

Immunofluorescence and live cell imaging; Flow cytometry, live cell tracking techniques; Vaccine development principles and rationale of vaccine design, different types of vaccines; Immunotherapy: rational, technology development; Development of monoclonal antibodies, applications in diseases including cancer therapy; Gene editing technology in designing antibody and applications; Designing antibody library for immunotherapy.

Elective 3: Pharmacokinetics and Pharmacodynamics

Duration: 60 hrs

Unit I: Pharmacokinetics (PK) and pharmacodynamics (PD) of drug-loaded nanomaterials in the human body (One- and two-compartment linear and nonlinear pharmacokinetics; Compartmental modelling with plasma and/or urinary data, Physiologically Based Compartment Models). Routes of excretion.

Unit II: Routes of administration of drug-loaded nanomaterials *in vivo*. Principles and methods of metabolic biotransformation; Disposition of xenobiotics in biological system

Unit III: PK describes a drug's exposure by characterizing its **ADME (Absorption, Distribution, Metabolism & Excretion)** properties and bioavailability as a function of time, PD describes a drug's response in terms of biochemical or molecular interactions. PK/PD together can be thought of as an exposure/response relationship.

Unit IV: PBPK models

PK and PD analyses are important because they help us understand how drugs behave in the body and how the body reacts to drugs, respectively. Drug developers use insights gained from PK and PD analyses to design better clinical studies (i.e., what dose to use or how different drugs interact with each other in the body). Clinicians use the information from PK and PD analyses (as presented in the drug label or package insert) to treat different types of patients (e.g., patients with and without renal impairment or elderly versus younger patients).

Elective 4: Nanobiosafety and nanotoxicology

Duration: 60 hrs

Unit I: Nanobiosafety: Opportunities, challenges and strategies for biosafety of nanomaterials; Biocompatibility, Toxicity, Safety Testing of nanomaterials in food, agriculture, environment and health. The safety of Manufactured Nanomaterials is an important concern impacting regulatory bodies throughout the world. Due to their size, Manufactured Nanomaterials may require additional testing beyond the standard suite of tests used for other chemicals, to ensure that the impact on human health and the environment is fully understood.

Unit II: Mechanisms Involved in Nanotoxicity: Hypersensitivity, Interaction of Materials with Soft Tissues, Inflammation, Granulation Tissue Formation, Foreign Body Reaction, Fibrosis, Cell Adhesion, Interactions with Hard Tissues, The Vroman Effect, Adhesion of Osteoblasts, Osseointegration, Fibrous Capsule Formation, Modification of Blood-Biomaterial Interactions: Interaction with Blood by Heparin, Interactions with Proteins,

Unit III: Organ toxicity: Systemic toxicity, Hepatotoxicity, cardiotoxicity, Renal toxicity, Crossing Blood Brain Barrier.

Unit IV: Assays for evaluation of Nanotoxicity: Cytotoxicity, ROS generation, Immunogenicity, Carcinogenicity, Genotoxicity; 3D microfluidics, 3D cultures, 3D Printing, 3D organ scaffolds, Skin Ethenic models

Elective 5: Cancer nanomedicine

Duration: 60 hrs

Unit I: Introduction to nanomedicine: Nanomedicine in drug delivery and detoxification; Nanomedicine in immunotherapy; Nanomedicine in diagnostics and bioimaging: multimodal diagnostics for the detection of cancer; Drug administration and transport by fluid motion; Drug dispersion and diffusion in biological systems; Drug permeation through biological barriers; Pharmacokinetics and biodistribution; Ligand-receptor engineering and targeted delivery; Drug loading and quantification; Controlled and responsive release; Combinatorial therapy and delivery; From bench to bedside translation; Case studies in nanomedicine

Unit III: Advanced drug and gene delivery: Passive versus active targeting. Surface modification of nanoparticles for targeting cancer. Externally activated therapies such as PDT, PTT, MHT, radiation therapy, etc., for the treatment of cancer. Nanoparticles overcoming the MDR effect of cancer. Image guided drug delivery and theranostics in cancer. Cancer immunotherapy using nanoparticles. Analysis of pre-clinical and clinical case studies for cancer treatment using nanoparticles.

Elective 6: Recombinant DNA technology and non-viral gene therapy

Duration: 60 hrs

Unit I: Recombinant DNA technology: Introduction, mutagenesis, cutting and re-joining. Polymerase chain reaction, Isolation and amplification of genes, gene expression genetic recombination: Transfer of characters, genetic recombination, phage crosses, and gene transfer mechanism.

Unit II: Genetic disorders and gene therapy: Single gene disorders, its molecular genetics, common diseases, auto-immune diseases, cancer, cardiovascular diseases, nervous disorders. Gene therapy: current Gene therapy of genetic disorders like cystic fibrosis, Thalassaemia, Neuroblastoma, hepatitis, AIDS, diabetes, haemophilia B etc.

Elective 7: Biosensors

Duration: 60 hrs

Unit I: Introduction: Definition, History, Properties of biosensors, Design features of biosensors, The biological component.

Unit II: Biomedical Sensors: Sensors and transducers: an overview, measurement systems, Classification of biomedical sensors and transducers, Why do we need Biomedical sensors and transducers. Important design considerations and system calibration. Commercial Examples of Biosensors: Opportunities and obstacles.

Unit III: Miniaturized devices in nanobiotechnology - types and applications, MEMS, Lab on a chip concept. Future of Biosensors and Transducers: Sensing Layer: The importance of computers in sensor and transducer technology,

Unit IV: Recent engineering solutions to health care using biosensors and transducers, Modern health care solutions.

Elective 8: Nanomedicine for neurological diseases

Duration: 60 hrs

Delivery of drug-loaded nanoparticles into the brain across the blood-brain barrier. Systemic versus localized (e.g. stereotaxic) delivery. Nanoparticles for the treatment of neurodegenerative disease such as Parkinson's Alzheimer's. Nanoparticles in the management of stroke. Image-guided surgery in the

brain. Analysis of pre-clinical and clinical case studies involving nanomedicine for treating neurological diseases.

Elective 9: Nanomedicine for pulmonary, hepatic and nephrological diseases

Duration: 60 hrs

Unit I: Pulmonary: Delivery of nanoparticles: Targeted drug delivery, non-invasive vs invasive administration; Concept of first-pass metabolism, Aerosolized delivery of drug-loaded nanoparticles in the deep lungs (alveoli), systemic absorption of drug. Nanoparticles in the treatment of asthama, bronchitis,

Unit II: Strategies Used in Nanoparticle Delivery in the GI tract: Time dependent, pH dependent; pressure dependent, enzyme dependent; Theragonostic Strategies,

Unit III: Accumulation of nanoparticles in Liver and Kidneys: hepatitis, etc. Image-guided surgery of kidney stones.

Elective 10: Nanomaterials in regenerative medicine

Duration: 60 hrs

Biodegradable nanomaterials as scaffolds in tissue engineering. Nanomaterials for stimulating stem and progenitor cells for differentiating into desired tissue types. Tissue repair and regeneration using nanoparticles. Analysis of pre-clinical and clinical case studies involving nanoparticle-mediated regenerative medicine.

Elective 11: Nanovaccines

Duration: 60 hrs

Elective 12: Industrial Pharmacy

Duration: 60 hrs

Open Elective 1:

Ethics in Research: Responsibilities to Society, Science, and Self

Credit: 2; Duration: 30 hrs

Open Elective 2:

IPR aspects, clinical trials and translational nanomedicine

Credit: 2; Duration: 30 hrs

Basic concepts of patents and intellectual property rights (IPR) involving nanoparticles for biomedical applications. History of nanoparticles in pre-clinical and clinical trials: case studies. Nanoformulations for biomedical applications in the market (e.g. abraxane).

Annexure I

MSc-Ph.D. Nanomedical Sciences

Duration 5 years

Semester I:

S. No.	Paper name	Paper topic	Credits
1	Core 1	Biomolecules and Biomacromolecules for Nanomedicine	4
2	Core 2	Introduction to Nanomaterials: Types and Synthesis	4
3	Core 3	Basic properties and Characterization of Nanopartilces	4
4	Practical 1	E) Basic nanoparticle synthesis F) Characterization studies of nanoparticles	4

Total Credit: 16

Semester II:

S. No.	Paper name	Paper topic	Credits
1	Core 4	Basics of cell biology and organ system	4
2.	Core 5	Nanomaterials for Diagnostics and therapeutic applications	4
3	Core 6	Interaction of nanomaterials with biological system	4
4	Practical 2	A)Basic nanoparticle interactions-Imaging B) *in vitro* studies using nanoparticles	4

Total Credit: 16 + Elective 4 + Open Elective 2 = 22

S. No.	Paper name	Paper topic	Credits
1	Elective 1*	Nanomaterials for antimicrobial applications	4
2	Elective 2*	Nanomaterials in regenerative medicine	4
3	Elective 3*	Pharmacokinetics and Pharmacodynamics	4
4.	Elective 4*	Nanobiosafety and nanotoxicology	4

Total Credit: 16 + Elective 4 + Open Elective 2 = 22

Semester III:

S. No.	Paper name	Paper topic	Credits
1	Elective 1*	Nanomaterials for antimicrobial applications	4
2	Elective 2*	Immune System and Innate Immunity	4
3	Elective 3*	Pharmacokinetics and Pharmacodynamics	4
4	Elective 4*	Nanobiosafety and Nanotoxicology	4
5	Elective 5*	Recombinant DNA technology and non-viral gene therapy	4
6.	Elective 6*	Cancer nanomedicine	4
6	Open elective 1	Ethics in Research: Responsibilities to Society, Science, and Self	2

5	Practical 3	Immunotechniques, Biotechniques, *in vivo* studies using nanoparticles	

* Any two

Semester IV:

S. No.	**Paper name**	**Paper topic**	**Credits**
1	Elective 7*	Biosensors	4
2	Elective 8*	Nanomedicine for neurological diseases	4
3	Elective 9*	Nanomedicine for pulmonary, hepatic and nephrological diseases	4
4	Elective 10*	Nanomaterials in regenerative medicine	4
5.	Elective 11*	Nanovaccines	4
6.	Elective 12*	Industrial Pharmacy	4
	Practical	Synthesis of micropartcles for vaccines, Immune responses in *in vivo* studies	4
	Semester IV		4
4	Open Elective 2	IPR aspects, clinical trials and translational nanomedicine	2
5	Project work	Six months	20

* Any two

Annexure -II

Core 1: Biomolecules and Bio-macromolecules for Nanomedicine

Duration: 60 hrs

Unit I: Nature, Properties and Function of Carbohydrates: Sugars-dissacharides, trioses, tetroses, pentoses, hexoses – stereoisomers – amino sugars, phosphosugars, sugar derivatives, deoxysugars - Oligossacharides-polyssacharides - homo and hetero polyssacharides, amylose, amylopectin, dextrans, limit dextran – starch - glycogensynthesis and degradation-glycolysis, TCA cycle, glycosyl moieties, cell wall polyssacharides – cellulose, chitin.

Unit II: Nature, Properties and Function of Lipids: Fats, Oils, Waxes; Fatty acids:
types, saturated, unsaturated, essential, short and long chain; triglycerides, lipids and cholesterol; Biosynthesis of fatty acid/triglyceride/cholesterol and Biological oxidation/degradation of alpha, beta and omega fatty acids.

Unit III: Nature, Properties and Function of Proteins: Amino acids: Essential and non-essential amino acids, dipeptides, oligipeptides, polypeptides. monomers, dimers, oligomers; fibrous proteins and globulins; primary, secondary, tertiary, quarternary structures; disulfides, hydrogen bonds, Schiff's base- amino and carboxy termini - alpha helix and beta plates; triple helix; Ramachandran plots.

Unit IV: Nature, Properties and Function of Nucleic acids: Nitrogen bases-purines, pyrimidines, nucleosides and nucleotides-oligonucleotides - base paring- DNA, RNA-tRnNA, mRNA, rRNA, antisense RNA-linear and circular forms, single and double stranded; hypo and hyperchromicity-extra chromosomal DNA- mitochondrial, choloroplastic, plasmid and viral – microsatellites – DNA varieties – A, B, and Z – Okazaki fragment – palindrome-concatenation- polymorphism – mutation – strand breaks – genes – promoters, enhancers, structural genes - gene expression – gene silencing - transposons – telomeres.

Core 2: Introduction to Nanomaterials: Types and Synthesis

Duration: 60 hrs

Unit I: Types of nanomaterials: polymeric, Liposomes, Micelles, lipid-based, hydrogels, metal-based, semiconductor-based, hybrid, Dendrimers, Quantum dots etc.

Unit II: Nanomaterial synthesis: Microemulsion, templated synthesis, hot colloidal method, sol-gel method, co-precipitation methods, etc. Phase-transfer and surface coating/bioconjugation. Basic characterization using electron microscopy, IR and optical spectroscopy, elemental analysis, x-ray diffraction, etc.

Unit III: Properties of nanomaterials in Medicine, Properties of Materials: Bulk Properties of Materials, Surface Properties of Materials. Classes of Materials Used in Medicine: Structure and Properties of Metals, Ceramics, Glasses, and Glass-Ceramics, Polymers, Hydrogels, Family of Carbon Nanomaterials, Bioresorbable and Bioerodible Materials, Composites, Thin Films, Grafts and Coatings, Biologically Functional Materials.

Unit IV: Materials classification by bonding, amorphous and crystalline materials, crystal lattices, Miller Indices, Bragg's Law, Defects in crystal structure, principles of dislocations, theory of diffusion, mechanical properties, phase diagrams, polymeric materials, composite materials, corrosion, electrical and optical properties, types of nanomaterials, surfaces and particle size, surface energy and surface tension and relation to size, phase transformations in nanomaterials, specific heat and heat capacity of nanomaterials, mechanical properties of nanomaterials, optical properties of nanomaterials, electrical and magnetic properties of nanomaterials, carbon-based nanomatertials.

Core 3: Basic properties and Characterization of Nanoparticles

Duration: 60 hrs

Unit I: State of the art techniques for measuring nanoparticle size distribution Basics of transmission and scanning electron microscopy, instrumentation, sample preparation, negative staining, data analysis and interpretation, selected area electron diffraction (SAED).

Unit II: Characterization techniques of nanomaterials: Basic principles of dynamic light scattering (DLS), diffusion coefficients, size determination using Stokes-Einstein equation. X-ray diffraction techniques, Bragg's law, Miller indices, Scherrer equation. UV-visible-NIR absorbance, fluorescence, and photoluminescence (PL) spectroscopies, Lambert Beer's law, quenching of fluorescence, Stern-Volmer's equation, fluorescence resonance energy transfer (FRET).

Unit III: Basics of functional group analysis: using IR, FTIR and NMR spectroscopies. Elemental analysis using Energy dispersive X-ray (EDX) and x-ray photoelectron (XPS) spectroscopies. Analysis of magnetic properties using vibrating-sample magnetometer (VSM) or superconducting quantum interference device (SQUID) magnetometer.

Unit IV: Surface and porosity analysis using BET technique. BJH isotherm for pore-size analysis; Basics of DTA, TGA, and DSC techniques.

Core 4: Basics of cell biology and organ system

Duration: 60 hrs

Section A: Biology of Cell and Cell Function:

Unit I: Cell as unit of life. Prokaryotes and Eukaryotes cells- Structure and functions. Ultrastructure of plant, animal and microbial cells. Types of cells: Glial, Astrocytes, Oligodendroglia, Fibroblasts;

Unit II: Cell cycle and regulation: The cell cycle and its control system, Interphase, Mitosis, Cytokinesis and molecular regulation, cell transformation, cell death and apoptosis. Unit **Intercellular communication**: Transport mechanisms across membrane, Cell signaling, Cell junctions, Cell adhesion and the extracellular matrix, Specialized cells, tissues, **Cell proliferation and differentiation**: pluripotency, totipotency, progenitor cells, differentiated cells; Membrane transport, nuclear transport, transcription, translation; Cell communication and Cell signalling-hormones, cytokines-natural products.

Section B: Human Physiology and Pathophysiology

Unit III: Introduces major topics in human physiology, emphasizing knowledge essential to health-related laboratory research. Topics include neurophysiology, immunology, cardiovascular, respiratory, renal, and gastrointestinal physiology and endocrinology.

Unit IV: Systems Physiology: General introduction to systems physiology. Homeostasis, function, and common pathological conditions in various human organ systems including: Cardiovascular and circulatory system, nervous system, renal system, gastrointestinal and hepatobiliary system, reproductive system, skin, pulmonary system, vision and auditory systems, ear, nose and throat, and the musculoskeletal system.

Core 5: Nanomaterials for diagnostics and therapeutics

Duration: 60 hrs

Section A: Diagnostics

Unit I: Application of core or probe-loaded nanoparticles in plasmonic, optical Imaging applications. Plasmonic nanoparticles and surface plasmon resonance (SPR) imaging, Fluorophore-loaded nanoparticles in advanced optical imaging.

Unit II: Cell Imaging, Multimodal bioimaging using nanoparticles. *In vitro* diagnostics and high throughput screening of disease biomarkers from body fluids. Nanomaterials in microfluidics.

Unit III: Magnetic nanoparticles in MRI imaging. Doping of diagnostic probes (e.g. gadolinium ions) with nanomaterials. Unique effects of drug interaction with nanomaterials: e.g. aggregation-enhanced emission.

Unit IV: Radio diagnostics: Radiochemistry and Radio Pharmacy; Introduction to Nuclear Medicine; Nanoparticles for PET and SPECT imaging; X-ray activated radiation diagnostics, CT imaging.

Section B: Therapeutics

Unit I: Drug encapsulation: Entrapment Efficiency, Loading Efficiency, surface conjugation (covalent *versus* non-covalent). Hydrophilic *versus* lipophilic drugs. Loading, retention and release studies. Enzyme-entrapment within nanomaterials. Fabrication of multifunctional nanoparticles. Stimuli-sensitive nanoparticles; Externally activated therapies such as photodynamic therapy (PDT), photothermal therapy (PTT) and magnetic hyperthermia therapy (MHT).

Unit II: Drug Delivery: Active *vs* passive, Controlled, Sustained and targeted drug delivery. Inorganic Nanoparticles; Lipid Nanoparticles; Peptide/DNA Coupled Nanoparticles for Drug Delivery; Metal/Metal Oxide Nanoparticles (antibacterial/anti-fungal/anti-viral); Anisotropic and Magnetic Particles (Hyperthermia). Interaction of nanomaterials with active agents such as drugs, photosensitizers and genes.

Unit III: Nuclear therapy: Nanoparticles loaded with radioisotopes (e.g. alpha or beta emitters); X-ray activated radiation therapy, Particle therapy involving interaction of ion beams with nanoparticles. Image-guided therapeutics and theranostic applications involving nanoparticles.

Core 6: Interaction of nanomaterials with biological system

Duration: 60 hrs

Unit I: Biophysicochemical influences on the interface between nanomaterials and biological systems: Size, shape, surface area, Surface charge, energy, roughness and porosity, Valence and conductance states. Functional groups, Ligands, Crystallinity and defects; Hydrophobicity and hydrophilicity.

Unit II: Suspending media: Water molecules; Acids and bases; Salts and multivalent ions Natural organic matter (humics, proteins, lipids) Surfactants; Polymers; Polyelectrolytes; **solid–liquid interface**: Surface hydration and dehydration; Surface reconstruction and release of free surface energy; Ion adsorption and charge neutralization; Electrical double-layer formation, zeta potential, isoelectric point; Sorption of stearic molecules and toxins; Electrostatic, stearic and electrostearic interactions Aggregation, dispersion and dissolution;

Unit III: Probing nano-bio interface interactions between NPs and cell membrane: specific and nonspecific forces; Receptor–ligand binding interactions Membrane wrapping: resistive and promotive forces; Biomolecule interactions (lipids, proteins, DNA) leading to structural and functional effects; Free energy transfer to biomolecules; Conformational change in biomolecules; Oxidant injury to biomolecules; Mitochondrial and lysosomal damage, decrease in ATP.

Unit IV: Routes of cellular entry: Protein corona; endocytosis, pinocytosis, phagocytosis, etc. Intracellular distribution and accumulation of nanoparticles.

Discipline Specific Electives

Elective 1: Nanomaterials for antimicrobial applications

Duration: 60 hrs

Interaction of nanomaterials with bacterial, viral, fungal strains. Antibacterial function of metal nanoparticles. Amphotericin-B loaded nanoparticles for treating fungal infections. Drug and gene-loaded nanoparticles for treating viral diseases. Light and magnetic-field activated nanoparticles for hyperthermia-based microbial decontamination. Nanoparticle-based bandages for treating infected wounds. Analysis of pre-clinical evaluation of antimicrobial effects of nanoparticles.

Elective 2: Immune System & Innate Immunity

Duration: 60 hrs

Unit I: Introduction to the Immune System & Innate Immunity: Primary and secondary lymphoid organs; Cells of the immune system; Innate Immunity as first line of host defense, distinction between self and non-self, complement system- classical and alternative, Types of innate immune cells and their functions in immune responses, Molecules of innate cells, Response of the innate immune systems to pathogens.

Unit II: Molecules & Cells of the Adaptive Immune System: Antigens: chemical and molecular nature, adjuvants and their functions; Recognition of antigen by B-cell and T-cell Receptors; Generation of lymphocyte antigen receptors (antibodies and TCR), Antigen presentation by Major histocompatibility complex molecules. Antigen receptor structure and signaling pathways, Generation of lymphocytes in bone marrow and thymus, Survival and maturation of lymphocytes in peripheral lymphoid tissues.Adaptive Immune Response: T Cell-Mediated Immunity, the production of armed effector T cells, General properties of armed effector T cells, T cell-mediated cytotoxicity; Humoral immune response, B-cell activation by armed helper T cells, Adaptive immunity to infection, Infectious agents and how they cause disease, The course of the adaptive response to infection, mucosal immune system, Immunological memory

Unit III: Immune System in Health and Disease: Pathogen response to immune system, Immunodeficiency diseases, Allergy and hypersensitivity; Autoimmunity and transplantation; Disorders of immune response: IBD and MS: a case study; Cancer immunology.

Unit IV: Immunotechniques: Principles of immunization, techniques for analysis of immune response, antibody related techniques; Hybridoma, epitope mapping; Immuno assays: RIA, ELISA, Immunoblotting, ELISPOT,

Immunofluorescence and live cell imaging; Flow cytometry, live cell tracking techniques; Vaccine development principles and rationale of vaccine design, different types of vaccines; Immunotherapy: rational, technology development; Development of monoclonal antibodies, applications in diseases including cancer therapy; Gene editing technology in designing antibody and applications; Designing antibody library for immunotherapy.

Elective 3: Pharmacokinetics and Pharmacodynamics

Duration: 60 hrs

Unit I: Pharmacokinetics (PK) and pharmacodynamics (PD) of drug-loaded nanomaterials in the human body (One- and two-compartment linear and nonlinear pharmacokinetics; Compartmental modelling with plasma and/or urinary data, Physiologically Based Compartment Models). Routes of excretion.

Unit II: Routes of administration of drug-loaded nanomaterials *in vivo*. Principles and methods of metabolic biotransformation; Disposition of xenobiotics in biological system

Unit III: PK describes a drug's exposure by characterizing its **ADME (Absorption, Distribution, Metabolism & Excretion)** properties and bioavailability as a function of time, PD describes a drug's response in terms of biochemical or molecular interactions. PK/PD together can be thought of as an exposure/response relationship.

Unit IV: PBPK models

PK and PD analyses are important because they help us understand how drugs behave in the body and how the body reacts to drugs, respectively. Drug developers use insights gained from PK and PD analyses to design better clinical studies (i.e., what dose to use or how different drugs interact with each other in the body). Clinicians use the information from PK and PD analyses (as presented in the drug label or package insert) to treat different types of patients (e.g., patients with and without renal impairment or elderly versus younger patients).

Elective 4: Nanobiosafety and nanotoxicology

Duration: 60 hrs

Unit I: Nanobiosafety: Opportunities, challenges and strategies for biosafety of nanomaterials; Biocompatibility, Toxicity, Safety Testing of nanomaterials in food, agriculture, environment and health. The safety of Manufactured Nanomaterials is an important concern impacting regulatory bodies throughout the world. Due to their size, Manufactured Nanomaterials may require additional testing beyond the standard suite of tests used for other chemicals, to ensure that the impact on human health and the environment is fully understood.

Unit II: Mechanisms Involved in Nanotoxicity: Hypersensitivity, Interaction of Materials with Soft Tissues, Inflammation, Granulation Tissue Formation, Foreign Body Reaction, Fibrosis, Cell Adhesion, Interactions with Hard Tissues, The Vroman Effect, Adhesion of Osteoblasts, Osseointegration, Fibrous Capsule Formation, Modification of Blood-Biomaterial Interactions: Interaction with Blood by Heparin, Interactions with Proteins,

Unit III: Organ toxicity: Systemic toxicity, Hepatotoxicity, cardiotoxicity, Renal toxicity, Crossing Blood Brain Barrier.

Unit IV: Assays for evaluation of Nanotoxicity: Cytotoxicity, ROS generation, Immunogenicity, Carcinogenicity, Genotoxicity; 3D microfluidics, 3D cultures, 3D Printing, 3D organ scaffolds, Skin Ethenic models

Elective 5: Cancer nanomedicine

Duration: 60 hrs

Unit I: Introduction to nanomedicine: Nanomedicine in drug delivery and detoxification; Nanomedicine in immunotherapy; Nanomedicine in diagnostics and bioimaging: multimodal diagnostics for the detection of cancer; Drug administration and transport by fluid motion; Drug dispersion and diffusion in biological systems; Drug permeation through biological barriers; Pharmacokinetics and biodistribution; Ligand-receptor engineering and targeted delivery; Drug loading and quantification; Controlled and responsive release; Combinatorial therapy and delivery; From bench to bedside translation; Case studies in nanomedicine

Unit III: Advanced drug and gene delivery: Passive versus active targeting. Surface modification of nanoparticles for targeting cancer. Externally activated therapies such as PDT, PTT, MHT, radiation therapy, etc., for the treatment of cancer. Nanoparticles overcoming the MDR effect of cancer. Image guided drug delivery and theranostics in cancer. Cancer immunotherapy using nanoparticles. Analysis of pre-clinical and clinical case studies for cancer treatment using nanoparticles.

Elective 6: Recombinant DNA technology and non-viral gene therapy

Duration: 60 hrs

Unit I: Recombinant DNA technology: Introduction, mutagenesis, cutting and re-joining. Polymerase chain reaction, Isolation and amplification of genes, gene expression genetic recombination: Transfer of characters, genetic recombination, phage crosses, and gene transfer mechanism.

Unit II: Genetic disorders and gene therapy: Single gene disorders, its molecular genetics, common diseases, auto-immune diseases, cancer, cardiovascular diseases, nervous disorders. Gene therapy: current Gene therapy of genetic disorders like cystic fibrosis, Thalassaemia, Neuroblastoma, hepatitis, AIDS, diabetes, haemophilia B etc.

Elective 7: Biosensors

Duration: 60 hrs

Unit I: Introduction: Definition, History, Properties of biosensors, Design features of biosensors, The biological component.

Unit II: Biomedical Sensors: Sensors and transducers: an overview, measurement systems, Classification of biomedical sensors and transducers, Why do we need Biomedical sensors and transducers. Important design considerations and system calibration. Commercial Examples of Biosensors: Opportunities and obstacles.

Unit III: Miniaturized devices in nanobiotechnology - types and applications, MEMS, Lab on a chip concept. Future of Biosensors and Transducers: Sensing Layer: The importance of computers in sensor and transducer technology,

Unit IV: Recent engineering solutions to health care using biosensors and transducers, Modern health care solutions.

Elective 8: Nanomedicine for neurological diseases

Duration: 60 hrs

Delivery of drug-loaded nanoparticles into the brain across the blood-brain barrier. Systemic versus localized (e.g. stereotaxic) delivery. Nanoparticles for the treatment of neurodegenerative disease such as Parkinson's Alzheimer's. Nanoparticles in the management of stroke. Image-guided surgery in the

brain. Analysis of pre-clinical and clinical case studies involving nanomedicine for treating neurological diseases.

Elective 9: Nanomedicine for pulmonary, hepatic and nephrological diseases

Duration: 60 hrs

Unit I: Pulmonary: Delivery of nanoparticles: Targeted drug delivery, non-invasive vs invasive administration; Concept of first-pass metabolism, Aerosolized delivery of drug-loaded nanoparticles in the deep lungs (alveoli), systemic absorption of drug. Nanoparticles in the treatment of asthama, bronchitis,

Unit II: Strategies Used in Nanoparticle Delivery in the GI tract: Time dependent, pH dependent; pressure dependent, enzyme dependent; Theragonostic Strategies,

Unit III: Accumulation of nanoparticles in Liver and Kidneys: hepatitis, etc. Image-guided surgery of kidney stones.

Elective 10: Nanomaterials in regenerative medicine

Duration: 60 hrs

Biodegradable nanomaterials as scaffolds in tissue engineering. Nanomaterials for stimulating stem and progenitor cells for differentiating into desired tissue types. Tissue repair and regeneration using nanoparticles. Analysis of pre-clinical and clinical case studies involving nanoparticle-mediated regenerative medicine.

Elective 11: Nanovaccines

Duration: 60 hrs

Elective 12: Industrial Pharmacy

Duration: 60 hrs

Open Elective 1:

Ethics in Research: Responsibilities to Society, Science, and Self

Credit: 2; Duration: 30 hrs

Open Elective 2:

IPR aspects, clinical trials and translational nanomedicine

Credit: 2; Duration: 30 hrs

Basic concepts of patents and intellectual property rights (IPR) involving nanoparticles for biomedical applications. History of nanoparticles in pre-clinical and clinical trials: case studies. Nanoformulations for biomedical applications in the market (e.g. abraxane).