UNIVERSITY OF KASHMIR
NAAC ACCREDITED A++

CURRICULUM DEVELOPED

FOR

M.Sc. PROGRAMME IN NANOTECHNOLOGY

(NEP-2020 Scheme)

Placed before the PG Board of Studies in Nanotechnology for Approval

on

[23/06 /2025]

DEPARTMENT OF NANOTECHNOLOGY

UNIVERSITY OF KASHMIR

[2025-ONWARDS]

I. PROGRAMME OBJECTIVES:

M.Sc. Nanotechnology is a course designed for students to explore in-depth knowledge of nanoscience and technology and its application in various fields. To gain strength in this new interdisciplinary area, structure of the programme ensures comprehensive exposure to all domains of Nanoscience and Nanotechnology- covering the physics and chemistry of nanomaterials, methods of synthesis and their characterizations, properties of nanomaterials, nanosystems design and mathematics for nanotechnology. Key feature of the programme is its diversity and inclusivity with courses on cell and molecular biology for bioengineering, nano-biomaterials and their interactions with cells and applications of nanotechnology in various areas- multifunctional nanostructures; nanomedicine- diagnostics and therapeutics for human diseases like diabetes, cancer and neurodegenerative diseases, bioengineering scaffolds for regenerative medicine, and the engineering of nanosensors & devices for disease diagnostics and therapeutics; nanotechnology for environmental engineering, sustainable agriculture & food technology.

This is a pioneering programme that aims to develop a competent and technologically advanced human resource in the interdisciplinary areas of nanotechnology- nanophotonics, chemical nanoengineering, nanomedicine, nanosensors, bioengineering and regenerative medicine. The programme with its uniquely blended and advanced course design provides sufficient hands-on training to the students for development and characterization of nanomaterials for various diverse applications. Additionally, a full fourth semester research intensive internship is offered, wherein students complete dissertations in topics of choice pertaining to synthesis of multifunctional nanostructures and their characterizations for various applications- nanomedicine and therapeutics, tissue engineering and regenerative medicine, environment, energy, agriculture, food or in any related disciplines of Nanoscience and Nanotechnology.

II. PROGRAMME LEARNING OUTCOMES (PLOs):

PROGRAMME LEARNING OUTCOMES (PLOs)		Masters Degree in Nanotechnology
PLOs		After the completion of Masters degree in Nanotechnology, students will be able to:
PLO-1:	Understanding of Nanoscience Principles	Conceptualize the principles of Nanoscience and Nanotechnology for design and fabrication of smart nanostructures with unique and novel properties for advanced applications.
PLO-2:	Interdisciplinary Scientific Integration	Integrate core concepts from multiple domains of science- Physics, Chemistry, Biology and Engineering to design, fabricate and characterize novel materials & interpretation of data to draw conclusions for cohesive material advancement.
PLO-3:	Nanomaterials in Diverse Applications	Attain comprehensive knowledge on the use of advanced nanomaterials across multiple sectors like, nanomedicine and therapeutics, nanoelectronics and nanosensors, bioengineering and regenerative medicine, environmental engineering, agriculture, food, etc.
PLO-4:	Safety, Environmental and Ethical Awareness	Acquire knowledge of environment, health, and safety implications of nanomaterials, promoting responsible development, application and disposal besides following ethical considerations in all aspects of research and development.
PLO-5:	Integration of IKS and Sustainability	Demonstrate awareness of Indian Knowledge Systems (IKS), sustainability principles, and their relevance in the development and application of Nanotechnology.
PLO-6:	Interdisciplinary Impact and Scientific Extension	Gain understanding of how nanotechnology impacts key industrial sectors while encouraging the extension of foundational scientific knowledge to related disciplines.
PLO-7:	Communication Skills	Express the ability to communicate effectively on scientific topics, write & comprehend effective scientific reports, and make effective presentations.
PLO-8:	Research Advancement	Apply critical thinking, appropriate research methodology, deeper analysis of research problems and skill to pursue advanced research in nanotechnology.
PLO-9:	Professionalism and Leadership	Demonstrate professionalism, right attitude, teamwork, responsibility and leadership, thus preparing them to thrive in complex, diverse, and modern work environments.
PLO-10:	Career-Oriented Skill Development/ Industry Exposure and Entrepreneurship	Apply knowledge and skills acquired through advanced training for stepping into diverse career domains in nanotechnology and related interdisciplinary and multidisciplinary areas / Inspire innovation and entrepreneurship, supporting the development of startups through hands-on training and industry exposure.

Semester	Core Papers (Core Course/Elective)	Course Level	Credits	Total Mandatory Credits	Max. Marks			Credit Distribution	Learning Hours
	Course Name / Course Code				Internal	External	Total	L:T:P	
I	Essentials of Nanoscience and Nanotechnology (CR) / MNTYCEN125	400	3	20	21	54	75	3:0:0	45
	Concepts of Physics (CR) / MNTYCCP125	400	2		14	36	50	2:0:0	30
	Biomolecules: Structural & Functional Principles for Nanomedicine (CR) / MNTYCBN125	400	3		21	54	75	3:0:0	45
	Carbon Nanostructures and Porous Materials (CR) / MNTYCCN125	400	2		14	36	50	2:0:0	30
	Fundamentals of Cell Biology for Bioengineering (CR) / MNTYCCB125	400	3		21	54	75	3:0:0	45
	Molecular Biology: Fundamentals and Laboratory Approaches (CR) / MNTYCMB125	400	3		21	54	75	3:0:0	45
	Nanoscience & Technology Lab-I (CR) / MNTYCNL125	500	2		14	36	50	0:0:4	60
	Elective Course: One course to be selected								
	Mathematics in Nanotechnology (DCE) / MNTYDMN125	400	2		14	36	50	2:0:0	30
	Laboratory Safety Course (DCE) / MNTYDLS125	400	2		14	36	50	2:0:0	30
II	Synthesis of Nanomaterials: Physical & Chemical Approaches (CR) / MNTYCSN225	400	3	20	21	54	75	3:0:0	45
	Characterization Methods of Nanomaterials (CR) / MNTYCCM225	400	3		21	54	75	3:0:0	45
	Nano Biomaterials and Tissue Interactions (CR) / MNTYCNB225	400	3		21	54	75	3:0:0	45
	Concepts of Nanophysics (CR) / MNTYCNP225	400	2		14	36	50	2:0:0	30
	Molecular Basis of Disease (CR) / MNTYCMD225	400	2		14	36	50	3:0:0	30
	Principles and Techniques of Gene Manipulation (CR) / MNTYCGM225	400	3		21	54	75	3:0:0	45
	Nanoscience & Technology Lab-II (CR) / MNTYCNL225	500	2		14	36	50	0:0:4	60
	Elective Course: One course to be selected								
	Research Methodology and Ethics (DCE) / MNTYDRM225	400	2		14	36	50	2:0:0	30
	Concepts of Drug Design in Ayurveda (DCE) / MNTYDCD225	400	2		14	36	50	2:0:0	30
Exit option with Post-Graduate Diploma in Nanotechnology on completion of courses equal to a minimum of 40 credits or Entry to one year PG in Nanotechnology with course work and research									
III	Nanomaterials: Properties and Applications (CR) / MNTYCNP325	500	3	20	21	54	75	3:0:0	45
	Nanomedicine and Drug Delivery (CR) / MNTYCND325	500	2		14	36	50	2:0:0	30
	Principles of Regenerative Medicine & Tissue Engineering (CR) / MNTYCRM325	500	3		21	54	75	3:0:0	45
	Cancer Biology- Cellular Mechanisms and Targeted Therapies (CR) / MNTYCCB325	500	3		21	54	75	3:0:0	45
	Environmental, Agricultural & Food Nanotechnology (CR) / MNTYCEA325	500	3		21	54	75	3:0:0	45
	Nanoscience & Technology Lab-III ; Scientific Visit to Industry/ Research Institutes*# (CR) / MNTYCNL325	500	4		30	70	100	0:0:4#	120 *Includes Seminar Reports/lab#
	Elective Course: One course to be selected								
	Nanosensors & Devices (DCE) / MNTYDNS325	400	2		14	36	50	2:0:0	30
	Personality Development & Communication Skills (DCE) / MNTYDPC325	400	2		14	36	50	2:0:0	30
IV	Research Project: Project Presentation & Dissertation (CR) / MNTYCRP425	500	20	20	0	500	500	Research based experimental work	600 Full semester
Total			86	80	420	1580	2000		1620

Semester	Core Papers (Core Course/Elective) / Course Name / Course Code	Course Level	Credits	Total Mandatory Credits	Max. Marks			Credit Distribution	Learning Hours
					Internal	External	Total	L:T:P	
I	Essentials of Nanoscience and Nanotechnology (CR) / MNTYCEN125	400	3	20	21	54	75	3:0:0	45
	Concepts of Physics (CR) / MNTYCCP125	400	2		14	36	50	2:0:0	30
	Biomolecules: Structural & Functional Principles for Nanomedicine (CR) / MNTYCBN125	400	3		21	54	75	3:0:0	45
	Carbon Nanostructures and Porous Materials (CR) MNTYCCN125	400	2		14	36	50	2:0:0	30
	Fundamentals of Cell Biology for Bioengineering (CR) / MNTYCCB125	400	3		21	54	75	3:0:0	45
	Molecular Biology: Fundamentals and Laboratory Approaches (CR) / MNTYCMB125	400	3		21	54	75	3:0:0	45
	Nanoscience & Technology Lab-I (CR) / MNTYCNL125	500	2		14	36	50	0:0:4	60
	Elective Courses: One course to be selected								
	Mathematics in Nanotechnology (DCE) / MNTYDMN125	400	2		14	36	50	2:0:0	30
	Laboratory Safety Course (DCE) / MNTYDLS125	400	2		14	36	50	2:0:0	30
II	Synthesis of Nanomaterials: Physical & Chemical Approaches (CR) / MNTYCSN225	400	3	20	21	54	75	3:0:0	45
	Characterization Methods of Nanomaterials (CR) / MNTYCCM225	400	3		21	54	75	3:0:0	45
	Nano Biomaterials and Tissue Interactions (CR) / MNTYCNB225	400	3		21	54	75	3:0:0	45
	Concepts of Nanophysics (CR) / MNTYCNP225	400	2		14	36	50	2:0:0	30
	Molecular Basis of Disease (CR) / MNTYCMD225	400	2		14	36	50	3:0:0	30
	Principles and Techniques of Gene Manipulation (CR) / MNTYCGM225	400	3		21	54	75	3:0:0	45
	Nanoscience & Technology Lab-II (CR) / MNTYCNL225	500	2		14	36	50	0:0:4	60
	Elective Courses: One course to be selected								
	Research Methodology and Ethics (DCE) / MNTYDRM225	400	2		14	36	50	2:0:0	30
	Concepts of Drug Design in Ayurveda (DCE) / MNTYDCD225	400	2		14	36	50	2:0:0	30
Exit option with Post-Graduate Diploma in Nanotechnology on completion of courses equal to a minimum of 40 credits or Entry to one year PG in Nanotechnology with course work and research									
III	Nanomaterials: Properties and Applications (CR) / MNTYCNP325	500	3	20	21	54	75	3:0:0	45
	Nanomedicine & Drug Delivery (CR) / MNTYCND325	500	2		14	36	50	2:0:0	30
	Principles of Regenerative Medicine & Tissue Engineering (CR) / MNTYCRM325	500	3		21	54	75	3:0:0	45
	Cancer Biology- Cellular mechanisms and targeted therapies (CR) / MNTYCCB325	500	3		21	54	75	3:0:0	45
	Environmental, Agricultural & Food Nanotechnology (CR) / MNTYCEA325	500	3		21	54	75	3:0:0	45
	Nanoscience & Technology Lab-III; Scientific Visit to Industry/ Research Institutes*/# (CR) / MNTYCNL325	500	4		30	70	100	0:0:4#	120 (*Includes Seminar Reports/lab#)
	Elective Courses: One course to be selected								
	Nanosensors & Devices (DCE) / / MNTYDNS325	400	2		14	36	50	2:0:0	30
	Personality Development & Communication Skills (DCE) / MNTYDPC325	400	2		14	36	50	2:0:0	30
IV	Research Project: Project Presentation & Dissertation (CR) / MNTYCRP425	500	20	20	0	500	500	Research based experimental work	600 (Full semester)
Total			86	80	420	1580	2000		1620

SEMESTER-I

ESSENTIALS OF NANOSCIENCE AND NANOTECHNOLOGY	
Course Code: **MNTYCEN125**	Max. Marks: **75**
Contact Hours: **45**	External Examination: **54**
No. of credits: **03**	Internal Assessment: **21**

Course Learning Outcomes:

At the end of the course students will be able to:

- Acquire foundational knowledge of nanoscience and nanotechnology, and develop an understanding of nanoscale effects and their significance.
- Understand the unique nanoscale properties and how nanoscience integrates principles from physics, chemistry, biology, and engineering.
- Have an understanding of various nanomaterials, their classifications, and fundamental synthesis methods.

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCEN125.1	3	3	3	3	2.5	3	1.5	3	1	3	**2.6**
MNTYCEN125.2	3	3	3	3	2.5	3	1.5	3	1	3	**2.6**
MNTYCEN125.3	3	3	3	3	2.5	3	1.5	3	1	3	**2.6**
Average PLO	**3**	**3**	**3**	**3**	**2.5**	**3**	**1.5**	**3**	**1**	**3**	**2.6**

Unit-I (Lectures-15)

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

Unit-II (Lectures-15)

Materials and their types. Crystalline solids: close-packed structures, unit cells, two- and three-dimensional Bravais lattices, crystal systems, crystal planes and Miller indices, symmetry elements in crystals and molecules, point groups and space groups. Different types of magnetic materials, susceptibility and its temperature dependence, hysteresis and coercive force. Domain structure in ferromagnetic materials, antiferromagnetism and superexchange.

Unit-III (Lectures-15)

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

TEXT BOOKS/ REFERENCES:

1. Hornyak, Dutta, Tibbals and Rao, Introduction to Nanoscience and Nanotechnology, New York, CRC press, 2008.
2. Nanoscience and Nanotechnology in Engineering, VK Vardan, AS Pillai, Debashhish Mukherjee, Mayank Divedi, Linfeng Chen, 2009.
3. Introduction to Nanoscience, Stuart Lindsay, Oxford University Press, 2010.
4. Introductory Nanoscience, Physical and Chemical concepts, Masaru Kuno, 2011.
5. Solid State Chemistry and its Applications by AR West. 2014.
6. Nanostructures and Nanomaterials, Synthesis, Properties, and Applications, G. Cao and Y. Wang, 2011
7. Introduction to Nanotechnology by Charles P. Poole Jr & Frank J. Owens, 2003.

CONCEPTS OF PHYSICS

Course Code: **MNTYCCP125**	Max. Marks: **50**
Contact Hours: **30**	External Examination: **36**
No. of credits: **02**	Internal Assessment: **14**

Course Learning Outcomes:

At the end of the course students will be able to:

- Describe and apply Drude theory to understand charge carriers in metals, as well as analyze thermal conductivity, Hall effect, and magneto-resistance
- Derive Bragg's equation/law from diffraction principles, apply it to crystal structures, and interpret diffraction patterns to study both crystalline and non-crystalline solids
- Explain the types of bonding (covalent, ionic, molecular) in solids, and calculate their cohesive energies to understand material properties
- Apply Bloch's theorem to describe electron states in crystals and analyse semiconductor properties, magnetic phenomena, and superconductivity, including the Meissner effect and Type-I/II superconductors

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCCP125.1	3	3	3	3	1	3	3	3	1.5	1.5	**2.5**
MNTYCCP125.2	3	3	3	3	1	3	3	3	1.5	1.5	**2.5**
Average PLO	**3**	**3**	**3**	**3**	**1**	**3**	**3**	**3**	**1.5**	**1.5**	**2.5**

Unit-I (Lectures-15)

Metals: Drude theory, DC conductivity, Hall effect and magneto-resistance, AC conductivity, thermal conductivity, thermo-electric effects. Crystal Lattices: Bravais lattice, symmetry operations and classification of Bravais lattices, common crystal structures, X-ray diffraction, Bragg's law, Von Laue's formulation, diffraction from non-crystalline systems. Classification of Solids: Band classifications, covalent, molecular and ionic crystals, nature of bonding, cohesive energies, hydrogen bonding.

Unit-II (Lectures-15)

Electron States in Crystals: Periodic potential and Bloch's theorem, weak potential approximation, energy gaps. Semiconductors: General properties and band structure, carrier statistics, impurities, intrinsic and extrinsic semiconductors. Magnetism: Diamagnetism, paramagnetism of insulators and metals, ferromagnetism, Curie-Weiss law, introduction to other types of magnetic order. Superconductors: Phenomenology, review of basic properties, thermodynamics of superconductors, London's equation and Meissner effect, Type-I and Type-II superconductors.

TEXT BOOKS /REFERENCES:

1. C. Kittel, Introduction to Solid State Physics, Wiley, 2018.
2. N.W. Ashcroft and N.D. Mermin, Solid State Physics, Brooks/Cole, 2021.
3. J.M. Ziman, Principles of the Theory of Solids, Cambridge University Press, 1972.
4. A.J. Dekker, Solid State Physics, Macmillan, 2000.
5. G. Burns, Solid State Physics, Academic Press, 1985.
6. M.P. Marder, Condensed Matter Physics, Wiley, 2010.

BIOMOLECULES: STRUCTURAL AND FUNCTIONAL PRINCIPLES FOR NANOMEDICINE	
Course Code: **MNTYCBN125**	Max. Marks: **75**
Contact Hours: **45**	External Examination: **54**
No. of credits: **03**	Internal Assessment: **21**

Course Learning Outcomes:

At the end of the course students will be able to:

- Have a conceptual understanding of the structure and function of biomolecules and gain knowledge on the biomolecule-based nanostructures in cells
- Examine the functions of biomolecules that perform or trigger key metabolic activities and regulate physiological functions for the correct development and growth of the human body
- Understand the structure and role of proteins in biological systems
- Develop knowledge about enzymes that govern biochemical transformations and their importance in therapeutic applications
- Acquire a basic understanding of the biochemical reactions and develop concepts of key central metabolic pathways and energetics
- Comprehend important biochemical mechanisms responsible for common biochemical disorders and their significance for nanomedicinal interventions

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCBN125.1	3	3	3	2.5	2.5	2.5	1.5	3	1	3	**2.5**
MNTYCBN125.2	3	3	3	2.5	2.5	2.5	1.5	3	1	3	**2.5**
MNTYCBN125.3	3	3	3	2.5	2.5	2.5	1.5	3	1	3	**2.5**
Average PLO	**3**	**3**	**3**	**2.5**	**2.5**	**2.5**	**1.5**	**3**	**1**	**3**	**2.5**

Unit-I (Lectures-15)

Structure and function of carbohydrates- simple carbohydrates, homo and heteropolysaccharides, proteoglycans and glycosylaminoglycans. glyconanoparticles – examples and applications in theranostics. Structure and function of fatty acids, triacylglycerols and cholesterol. Lipid-based nanomaterials-Lipid-polymer nanoparticles and solid lipid nanoparticles. Basic structure, types and functions of nucleic acids-DNA and RNA – Examples and applications of DNA and RNA nanostructures.

Unit-II (Lectures-15)

Structure and function of proteins- primary, secondary, tertiary and quarternary structures. Protein nanoparticles. Enzymes and coenzymes, mechanism of action of enzymes and its regulation, kinetics of enzyme catalyzed reactions, Michaelis-Menten equation, importance of Vmax, Km, enzyme inhibition and activation. Applications of enzyme nanoparticles in day-day to life– Synzymes, ribozymes, Single Enzyme Nanoparticles (SENs).

Unit-III (Lectures-15)

Biomolecular transformations: Significance of carbohydrate, fatty acid and amino acid metabolism and their interrelationship in disease process. Overview of key central metabolic pathways- energetics and regulation. Concept of key biomolecular transformations in diseases like cancer, diabetes, cardiovascular, neurodegenerative and associated clinical disorders. Scope of biomolecule-based nanostructures in nanomedicine, brief overview of interplay between biomolecules and metabolic transformations in nanomedicine.

TEXT BOOKS /REFERENCES:

1. Fundamentals of Biochemistry: Life at the Molecular Level 5th Edition (2016), Authors: Donald Voet, Judith G. Voet & Charlotte W. Pratt, Publisher: John Wiley & Sons
2. Lehninger Principles of Biochemistry 8th Edition (2021), Authors: Michael Cox, David L. Nelson. Publisher: WH Freeman.
3. Keith J. Stine, Carbohydrate Nanotechnology (2015) Wiley, New Jersey.
4. The multiple faces of self-assembled lipidic systems. PMC Biophysics 2.1 (2009): 1-25.
5. DNA nanostructures at the interface with biology. Bujold, Katherine E., Aurélie Lacroix, and Hanadi F. Sleiman. Chem 4.3 (2018): 495-521.
6. Enzymes: Catalysis, Kinetics and Mechanisms (2025), Authors: Narayan S. Punekar. Publisher Springer, Singapore.
7. Enzyme nanoparticles: preparation, characterization, properties and applications. Pundir, Chandra S. William Andrew, UK, 2015.
8. Textbook Of Biochemistry With Clinical Correlations 7Ed, 2022, Devlin T.M , Publisher: John Wiley & Sons.
9. Nano-medicine therapy reprogramming metabolic network of tumour microenvironment: new opportunity for cancer therapies. (2024). Zhang, X., An, M., Zhang, J., Zhao, Y., & Liu, Y. *Journal of Drug Targeting*, *32*(3), 241–257.

CARBON NANOSTRUCTURES AND POROUS MATERIALS		
Course Code: **MNTYCCN125**	Max. Marks:	**50**
Contact Hours: **30**	External Examination:	**36**
No. of credits: **02**	Internal Assessment:	**14**

Course Learning Outcomes:

At the end of the course students will be able to:

- Understand different carbon nanostructures and porous materials, their classification and assessment of electrical, thermal and mechanical properties of carbon-based nanomaterials.
- Understand (macro/meso/micro/nanoporous) materials, including MOFs, COFs, aerogels, hydrogels, mesoporous silica, and the role of pore structures in multiple areas- energy storage, filtration, and biomedical applications.

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCCN125.1	3	3	2	2.5	2.5	2	1	3	1	2.5	**2.25**
MNTYCCN125.2	3	2	3	2	2	2	1	2.5	1	2.5	**2.1**
Average PLO	**3**	**2.5**	**2.5**	**2.25**	**2.25**	**2**	**1**	**2.75**	**1**	**2.5**	**2.17**

Unit-I (Lectures: 15)

Carbon-based nanomaterials- Discovery of C60, Graphene Sheet to a Nanotube, Single-walled and Multi-walled Nanotubes, Zigzag and Armchair Nanotubes, Classification, idealized structure of CNTs and properties. Carbon Nanofoam, carbon-based quantum dots, electrical, mechanical, thermal, and optical properties. Applications of CNTs and their composites, Carbon Nanofoam and its applications. Toxicity associated with carbon-based nanomaterials and activated carbon properties and synthesis.

Unit-II (Lectures: 15)

Structure and Properties of porous material - Natural vs. synthetic porous materials, Macro, meso, micro and nanoporous materials; natural and synthetic porous materials – Zeolites and metal-organic frameworks (MOFs), covalent organic framework (COF), mesoporous silica and carbon-based materials; Nanomembranes and Molecular sieves, foams, nanosponges, aerogels, hydrogels, porosity measurements, role of pore structures in various areas- energy storage, filtration, biomedical applications.

TEXT BOOKS/ REFERENCES:

1. Carbon Nanotubes: Recent Progress. (2018). By Abdullah Mohammed Asiri, Mohammed Rahman, United Kingdom: Intech Open.
2. Porous Materials: Theory and Its Application for Environmental Remediation. (2022). - By Fernando Gómez-Granados, Juan Carlos Moreno-Piraján, Liliana Giraldo-Gutierrez, Springer International Publishing.
3. Advanced Functional Porous Materials: From Macro to Nano Scale Lengths. (2021). By Arya Uthaman, Hanna Maria, Sabu Thomas, Tianduo Li, Switzerland: Springer International Publishing.
4. Handbook of Carbon-Based Nanomaterials. (2021). By Juan Carlos Moreno-Piraján, S.A Hangovan, Sabu Thomas, Sarathchandran C. Netherlands: Elsevier.

5. Porous Materials: Process technology and applications. (2013) By Ishizaki, Kozo, Sridhar Komarneni, and Makoto Nanko, Vol. 4. Springer Science & Business media.

FUNDAMENTALS OF CELL BIOLOGY FOR BIOENGINEERING

Course Code: **MNTYCCB125**	Max. Marks:	**75**
Contact Hours: **45**	External Examination:	**54**
No. of credits: **03**	Internal Assessment:	**21**

Course Learning Outcomes:

At the end of the course students will be able to:

- Gain a comprehensive introduction to the fundamentals of cell biology- cell as a basic unit of life, internal organization of cells, molecular basis of membrane transport, intracellular membrane traffic.
- Understand general principles of cell signaling, communication between cells and the exterior, role of the cytoskeleton and cellular nanomachines in transport and cell division.
- Understand the role of ECM in tissue formation, scope of ECM mimicry in the design of tissue engineering constructs, and acquire concepts in systems biology & synthetic biology for bioengineering applications.

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCCB125.1	2.5	3	3	2.5	2	3	1	2.5	1	3	**2.35**
MNTYCCB125.2	2.5	3	3	3	2	3	1	2.5	1.5	3	**2.45**
MNTYCCB125.3	2.5	3	3	2.5	2	3	1	2.5	1	3	**2.35**
Average PLO	**2.5**	**3**	**3**	**2.66**	**2**	**3**	**1**	**2.5**	**1.16**	**3**	**2.38**

Unit I: (Lectures: 15)

Universal features of cells and how these features separate the living world from non-living world, Cells and laws of thermodynamics; Cell membrane- structure; Internal organization of cells: Compartmentalization of cells, Intracellular membrane traffic, Maintenance of compartmental diversity, Transport of small molecules across the membranes and electrical properties of membranes, Types of membrane transport and examples of molecular mechanisms involved in transport.

Unit II: (Lectures: 15)

General principles governing cell signaling, Cytoskeleton - Types of cytoskeletal filaments, Molecular mechanisms involved in self-assembly and dynamic structure of cytoskeletal filaments, Cellular nanomachines - Molecular motors and their significance in intracellular transport and cell division. Cell cycle: regulation of growth and development.

Unit III: (Lectures: 15)

Contacts between cell to cell and cells to extracellular matrix (ECM) - Cell adhesions, Extracellular Matrix; Types of Junctions between Cells and Extracellular Matrix (ECM); Role of ECM in tissue formation and regulating organ structure & function, ECM

dysregulation and disease. Mimicking of biological materials or environments: ECM-mimicking and scope in tissue engineering constructs. Overview of Systems Biology, Synthetic Biology principles in Bioengineering.

TEXT BOOKS/ REFERENCES:

1. Alberts B, Johnson A, Lewis J, Raff M, Roberts K and Walter P, "Molecular Biology of the Cell", Fifth and Sixth Editions, Garland Publishing Inc. 2008.
2. Gerald Karp, "Cell and Molecular Biology", Fifth Edition, John Wiley, 2008.
3. Principles of Regenerative Medicine, Anthony Atala, Robert Lanza James, Thomson Robert Nerem, 2nd Edition, Elsevier -2010
4. Review articles and reference study material will be provided to students.

MOLECULAR BIOLOGY: FUNDAMENTALS AND LABORATORY APPROACHES

Course Code: **MNTYCMB125**	Max. Marks: **75**
Contact Hours: **45**	External Examination: **54**
No. of credits: **03**	Internal Assessment: **21**

Course Learning Outcomes:

At the end of the course students will be able to:

- Introduce molecular mechanisms of cellular life, including DNA replication, repair, transcription, translation, gene regulation, and biotech applications
- Understand PCR, gene cloning, and DNA sequencing
- Emphasize experimental design, data interpretation, and critical thinking skills

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYDMB125.1	3	3	2	2	2	3	1	3	2	3	2.4
MNTYDMB125.2	3	3	2.5	2	2	3	1	2.5	2	3	2.4
MNTYDMB125.3	3	3	2	2.5	2	3	1	2.5	2	3	2.4
Average PLO	3	3	2.16	2.16	2	3	1	2.66	2	3	2.4

Unit-I (Lectures-15)

DNA structure and organization. DNA chemical structure and physical properties. Chromatin structure and nucleosomes. Genome organization in prokaryotes vs. eukaryotes. DNA supercoiling and topoisomerases. Semi-conservative replication. DNA polymerases and replication machinery. Origins of replication and replication fork. Telomere replication. DNA damage types and consequences. DNA damage response pathways. DNA extraction and gel electrophoresis. Plasmid preparation and bacterial transformation.

Unit-II (Lectures-15)

RNA polymerases and general transcription factors. Promoter structure and recognition. Transcription initiation, elongation, and termination. RNA processing: 5' capping,

splicing, and 3' polyadenylation. Alternative splicing mechanisms. RNA editing and modification. Non-coding RNAs: types and functions. Genetic code and codon usage. tRNA and aminoacyl-tRNA synthetases. Ribosome structure and function. Translation initiation, elongation, and termination. Polyribosomes and co-translational protein folding. Post-translational modifications. PCR and primer design. Restriction enzyme digestion and gel electrophoresis.

Unit-III (Lectures-15)

Operon structure and function. Negative and positive regulation. Lac and Trp operons. Catabolite repression. Promoter and enhancer elements. General and specific transcription factors. Transcriptional activators and repressors. Coactivators and corepressors. Chromatin-mediated regulation. Histone modifications and chromatin remodeling. RNA interference and microRNAs. Translational regulation mechanisms. RNA localization, Protein stability and the ubiquitin-proteasome system.

TEXT BOOKS/REFERENCES:

- Alberts B, et al. Molecular Biology of the Cell. Garland Science., 2002.
- Watson JD, et al. Molecular Biology of the Gene. Cold Spring Harbor Laboratory Press. 2008.
- Krebs JE, et al. Lewin's Genes XII. Jones & Bartlett Learning, 2017.
- Green MR and Sambrook J. Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press, 2012.

NANOSCIENCE AND TECHNOLOGY LAB-I		
Course Code: **MNTYCNL125**	Max. Marks:	**50**
Contact Hours: **60**	External Examination:	**36**
No. of credits: **02**	Internal Assessment:	**14**

Course Learning Outcomes:

At the end of the course students will be able to:

- Have a hands-on laboratory training in preparation of solutions and buffers and understanding their biological relevance, importance in stabilization of chemical reactions and facilitation of industrial processes. Safety protocols, Handling of equipment.
- Understand the synthesis of nanomaterials and techniques for characterizations, estimation of biomolecules, molecular and cell biology techniques.
- Learn about the integration of advanced analytical tools like UV-Vis spectrophotometry, DLS, SPR, SEM, XRD, and fluorescence microscopy.
- Apply microscopy and staining methods to study microbial growth, cellular structures, and fluorescence-based assays.

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCNL125.1	3	3	1	2.5	2	2	2	3	3	2.5	2.4

List of Experiments:

1. Preparation of solutions and buffers of different pH, awareness of lab safety protocols, safe handling of lab equipment.
2. Synthesis of Ag nanoparticles DLS analysis and SPR studies.
3. Hydrothermal synthesis of ZnS Nanorods: SEM analysis and PL studies/ Synthesis of Ceria nanoparticles by co-precipitation method and size determination by XRD.
4. Contact angle determination as a means to evaluate hydrophilicity / hydrophobicity of nanomaterials.
5. Hydrothermal/solvothermal carbonization and activation methods (physical and chemical) for fabricating porous carbon-based nanomaterials for various applications and porosity measurements.
6. Isolation of Genomic DNA.
7. Quantitative and quantitative analysis of DNA and proteins.
8. Bacterial culture, competent cell preparation, Antibiotic resistance and plasmid transformation.
9. PCR-Amplification of genes for cloning in bacterial system.
10. Separation of peripheral mononuclear cells from blood samples.
11. Analysis and examination of samples by Fluorescence microscopy.

**Note: Lab exercises will be conducted as per the availability of required resources/ facilities*

MATHEMATICS IN NANOTECHNOLOGY

Course Code: **MNTYDMN125**	Max. Marks:	**50**
Contact Hours: **30**	External Examination:	**36**
No. of credits: **02**	Internal Assessment:	**14**

Course Learning Outcomes:

At the end of the course students will be able to:

- Have a grasp of core principles governing differentiation and integration
- Understand the foundational knowledge of Laplace transform and Fourier series methods for modeling and analyzing nanotechnology systems
- Apply techniques to nanostructure analysis, and nanomaterial characterization

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYDMN125.1	2.5	2.5	2.5	2	1	2.5	1.5	2.5	1	2.5	**2.05**
MNTYDMN125.2	3	3	3	2	1	2.5	1.5	2.5	1	2.5	**2.2**
Average PLO	**2.75**	**2.75**	**2.75**	**2**	**1**	**2.5**	**1.5**	**2.5**	**1**	**2.5**	**2.12**

Unit-I (Lectures-15)

Basic concept of Differentiation and Integration with examples. Laplace Transforms: LT of elementary functions. Properties of LT; Linearity, First and second translation, change of scale property. LT of derivatives and integrals. Inverse LT; Inverse LT of some elementary functions. Solution of differential equations using LT.

Unit-II (Lectures-15)

Fourier series: Periodic functions, Dirichlet's conditions, Half range Fourier sine or cosine series. Convergence of FS. Fourier integral, Fourier transform and their properties. Applications of FT in spectroscopy (FT-IR and FT-NMR).

TEXT BOOKS/REFERENCES:

1. An Introduction to Laplace Transforms and Fourier Series" by P.P.G. Dyke, Springer, 2014
2. Fourier Analysis: An Introduction" by Elias M. Stein, Princeton University Press, 2003
3. Applied Partial Differential Equations: With Fourier Series and Boundary Value Problems" by Richard Haberman, Pearson College Div, 2012

LABORATORY SAFETY COURSE		
Course Code: **MNTYDLS125**	Max. Marks:	**50**
Contact Hours: **30**	External Examination:	**36**
No. of credits: **02**	Internal Assessment:	**14**

Course Learning Outcomes:

At the end of the course students will be able to:

- Understand core laboratory safety concepts, including chemical management, hazards, prevention, and biosafety principles.
- Explain biosafety levels, their purpose, importance, and regulatory/ethical compliance.
- Conduct and interpret biosafety risk assessments for procedures involving GMOs/LMOs and biological materials.
- Apply biosafety practices and emergency protocols (e.g., PPE, contamination control).
- Integrate safety knowledge to protect personnel, public health, and the environment.

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYDLS125.1	3	2	1.5	3	1.5	2	1.5	2.5	1	2.5	**2.05**
MNTYDLS125.2	2	3	1.5	3	2	1.5	2	2.5	1	2.5	**2.1**
Average PLO	**2.5**	**2.5**	**1.5**	**3**	**1.75**	**1.75**	**1.75**	**2.5**	**1**	**2.5**	**2.07**

Unit-I (Lectures- 15)

Responsibilities in laboratory and Basic laboratory safety practices. Chemical Managements - Introduction to chemical inventory and material safety data sheet - Chemical storage and chemical labelling - Transportation of chemicals in laboratory - Special chemical hazards. Introduction to Personal protective equipment's. Safe handling

of glassware's. Risk, Hazard, types of hazards. Risk Assessment; Risk management and communication.

Unit-II (Lectures- 15)

Biosafety- Introduction; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety, Levels and Guidelines Definition of GMOs & amp; LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis.

TEXTBOOKS/REFERENCES:

1. C. C. Fevzi and I. Adnan, Laboratory safety handbook, 1st Edition, 2016, Sabanci University
2.- John E. Smith, Biotechnology,3rd Ed. Cambridge University Press
3. Laboratory safety manual, Environmental Health and Safety Department, University of Washington, December 2021 Edition. (www.ehs.washington.edu)

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SEMESTER-II

SYNTHESIS OF NANOMATERIALS: PHYSICAL AND CHEMICAL APPROACHES	
Course Code: **MNTYCSN225**	Max. Marks: **75**
Contact Hours: **45**	External Examination: **54**
No. of credits: **3**	Internal Assessment: **21**

Course Learning Outcomes:

At the end of the course students will be able to:

- Study growth/nucleation principles, nanoparticle classification (organic, metal-based, hybrid), and top-down/bottom-up strategies
- Master nanomaterial synthesis by Physical and chemical methods- Inert gas condensation, Arc discharge, Ion sputtering, Laser ablation, Ball milling, Lithographic techniques, Pyrolysis and other methods, Spray Pyrolysis, Molecular beam epitaxy, Chemical vapor deposition method and other variants.
- Learn nanofiber fabrication (electrospinning, freeze-drying) and advanced fabrication methods (self-assembly, 3D printing), and innovative materials.

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCSN225.1	3	2.5	1	2	3	2	1	3	1.5	3	**2.2**
MNTYCSN225.2	3	3	1	2	2	2	1	2.5	1.5	3	**2.1**
MNTYCSN225.3	2.5	3	1	2	2	2	1	3	1.5	3	**2.1**
Average PLO	**2.83**	**2.83**	**1**	**2**	**2.33**	**2**	**1**	**2.83**	**1.5**	**3**	**2.13**

Unit-I (Lectures-15)

Fundamentals of growth and nucleation, classes of nanoparticles, e.g., organic, metal-based, hybrid including core/shell nanoparticles, top-down and bottom-up approaches, Nanomaterial synthesis by Physical methods- with suitable examples in each method: Inert gas condensation, Arc discharge, Ion sputtering, Laser ablation, Sputtering, Ball milling and its variants, Lithographic techniques, Pyrolysis and other methods, Spray Pyrolysis, Molecular beam epitaxy, Techniques of thin film deposition- Spray Coating, Strategies to improve the mechanical properties of nanocomposites.

Unit-II (Lectures-15)

Nanomaterial synthesis by chemical methods- common reducing agents and stabilizers. Solvothermal/hydrothermal route and mechanism of crystal growth by these processes, Sol-gel synthesis, Chemical vapor deposition method and other variants, Nanocrystals of semiconductors and other materials by arrested and co-precipitation, Oswald ripening, Sonochemical and microwave-assisted synthesis, Micelles and microemulsions. Polymeric nanoparticle synthesis by solvent evaporation, nanoprecipitation, salting-out, dialysis, an overview of the micelle, dendrimer, liposome formation and nanozyme synthesis.

Unit-III (Lectures-15)

Nanofibers synthesis: By drawing, templating, centrifugation, phase inversion, freeze drying, self-assembly, ultrasonication and different variants of electrospinning to form nanofibers - various parameters influencing nanofiber morphology, porosity and other characteristics. Synthesis of polyurethane, polypropylene and Nylon-6 fibers, and their synthesis. Synthesis of nanocomposite material -leaching, microsphere, phase-separation, 3D printing of materials

TEXT BOOKS/ REFERENCES:

1. Fundamentals of Nanoparticles: Classifications, Synthesis Methods, Properties and Characterization. (2018). By-Abdel Salam Hamdy Makhlouf, Ahmed Barhoum, Netherlands: Elsevier.
2. Synthesis of Inorganic Nanomaterials: Advances and Key Technologies. (2018). By Nandakumar Kalarikkal, Oluwatobi Samuel Oluwafemi, Sabu Thomas, Sneha Bhagyaraj, Netherlands: Woodhead Publishing.
3. Nanomaterials Synthesis: Design, Fabrication and Applications. (2019). By Nandakumar Kalarikkal, Sabu Thomas, Vanja Kokol, Yasir Beeran Pottathara, Yves Grohens, Netherlands: Elsevier Science.
4. Metal Nanoparticles: Synthesis, Characterization, and Applications (2001). By Fedlheim, D. L., Foss, C. A., United States: Taylor & Francis.
5. Green Nanoparticles: The Future of Nanobiotechnology. (2021). BY Srivastava, S., Bhargava, A. Singapore: Springer Nature Singapore.

CHARACTERIZATION METHODS OF NANOMATERIALS		
Course Code: **MNTYCCM225**	Max. Marks:	**75**
Contact Hours: **45**	External Examination:	**54**
No. of credits: **3**	Internal Assessment:	**21**

Course Learning Outcomes:

At the end of the course students will be able to:

- Identify key nanomaterial characterization techniques and understand their principles, including electron microscopy (SEM, TEM), XRD, spectroscopy (UV-Vis, FTIR, Raman), and surface analysis (AFM, BET).
- Select suitable tools based on nanomaterial properties and applications, and interpret data to assess structural, morphological, and compositional features
- Evaluate the strengths and limitations of each method and integrate multiple techniques for a comprehensive understanding and apply characterization skills to practical challenges in nanoscience and nanotechnology research.

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCCM225.1	3	3	3	2.5	2	1	1	3	1	3	2.25
MNTYCCM225.2	3	3	3	2	2.5	1	1	3	1	3	2.25
MNTYCCM225.3	3	3	3	2	2	1	1	3	1	3	2.2
Average PLO	3	3	3	2.16	2.16	1	1	3	1	3	2.23

Unit-I (Lectures-15)

Electron probe characterization methods. Limits of resolution, Rayliegh criteria and Abbes Equation. Abberations and types. Electron interaction with matter. Electron Microscopy Techniques. Scanning and Transmission Electron Microscopy (SEM & TEM) – operational principle and applications. Other important electron probe methods: Auger electron spectroscopy (AES) and Energy electron loss spectroscopy (EELS). Low energy electron spectroscopy (LEED).

Unit-II (Lectures-15)

Scanning probe microscopy techniques. Atomic Force Microscopy (AFM) and Scanning Tunnelling Microscopy (STM) – operational principle, types and applications. Spectral characterization of nanomaterials. IR, Raman, UV-Vis - and Photoluminescence (PL) Spectroscopy. X-ray photoelectron spectroscopy (XPS). Surface area and porosity (BET and BJH Analysis), Particle size determination by light scattering and surface charge on nanoparticles (Zeta potential).

Unit-III (Lectures-15)

X-ray Diffraction - operational principle and applications. Nano Perspective. Peak broadening and crystallite size. The Scherrer equation. Thermal analysis methods: Principle and Instrumentation of Thermogravimetry; Differential Thermal Analysis and Differential scanning calorimetry. Vibrating Sample Magnetometer and Electrochemical Characterization measurements (CV and EIS). Inductively-coupled plasma mass spectrometry (ICP-MS).

TEXT BOOKS/ REFERENCES:

1. J. Goldstein, D. E. Newbury, D.C. Joy, and C.E. Lym, "Scanning Electron Microscopy and X-ray Microanalysis", 2003.
2. D. Williams and B. Carter, "Transmission Electron Microscopy - A Textbook for Materials Science", Plenum Press, New York, 2nd Edition, 2009
3. Banwell C. N, Fundamental of molecular Spectroscopy, McGraw Hill, 1996.

4. Hornyak, Dutta, Tibbals and Rao, Introduction to Nanoscience and Nanotechnology, New York, CRC press, 2008.
5. Solid State Chemistry, AR West, 2014.
6. Nanostructures and Nanomaterials, Synthesis, Properties, and Applications, G. Cao and Y. Wang, 2011.

NANO BIOMATERIALS AND TISSUE INTERACTION

Course Code: **MNTYCNB225**	Max. Marks:	**75**
Contact Hours: **45**	External Examination:	**54**
No. of credits: **3**	Internal Assessment:	**21**

Course Learning Outcomes:

At the end of the course, students will be able to:

- Understand the basic concept of a biomaterial, comprehend the different types of biomaterials with their specific properties and applications in medicine
- Learn about the biological method for the synthesis of nanomaterials using plants, bacteria, fungi, and the advantages of using this method as a sustainable alternative
- Decipher the interactions of biomaterials with tissues and how nanoscale effects, influence the biological interactions.
- Learn about immunity modulating and anti-microbial properties of biomaterials.

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCNB225.1	3	3	3	3	2	3	1	3	1	3	**2.5**
MNTYCNB225.2	3	3	3	3	2.5	3	1	2.5	1	3	**2.5**
MNTYCNB225.3	3	3	3	3	2	3	1	2.5	1	3	**2.45**
Average PLO	**3**	**3**	**3**	**3**	**2.16**	**3**	**1**	**2.66**	**1**	**3**	**2.48**

Unit-I (Lectures: 15)

Introduction to the basic concepts of biomaterials science, Classes of biomaterials in Medicine: Natural biomaterials- protein-based biomaterials, cellulose-based biomaterials, natural composite biomaterials. Bioinspired design for novel biomaterials - Concepts of bioresorbable, bioinert, bioactive and biomimetic materials. Synthetic biomaterials - metals, ceramics, polymers, nanofibers, composites. Concept of biocompatibility and significance in medicine.

Unit-II (Lectures: 15)

Biological method for synthesis of nanomaterials - green synthesis of metal and metal oxide nanomaterials using plants, bacteria and fungi as reducing and capping agents. Role of various phytochemicals and enzymes as reducing and capping agents in the synthesis of nanomaterials. Advantages of employing biological method as a sustainable alternative for the synthesis of nanomaterials and their applications in nanomedicine.

Unit-III (Lectures: 15)

Protein and cell-material interactions, Blood-material interactions, Inflammatory, immune and angiogenic response to biomaterials, Influence of nanoscale physiochemical properties of biomaterials – porosity, mechanical strength, stiffness, surface characteristics & modifications on cellular interactions, biocompatibility, biodegradation. Immunity modulating and anti-microbial properties of biomaterials.

TEXT BOOKS / REFERENCES:

1. Biomaterials Science: An Introduction to Materials in Medicine, Edited by Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons. 2020
2. Green Nanoparticles: The Future of Nanobiotechnology. (2021). BY Srivastava, S., Bhargava, A. Singapore: Springer Nature Singapore.
3. Ying Deng and Jordan Kuiper, Functional 3D Tissue Engineering Scaffolds: Materials, Technologies, and Applications (Woodhead Publishing Series in Biomaterials), 2017
4. Cato T. Laurencin, Lakshmi S. Nair. Nanotechnology and Regenerative Engineering: The Scaffold, Second Edition, CRC Press 2017.

CONCEPTS IN NANOPHYSICS		
Course Code: **MNTYCNP225**	Max. Marks:	**50**
Contact Hours: **30**	External Examination:	**36**
No. of credits: **2**	Internal Assessment:	**14**

Course Learning Outcomes:

At the end of the course students will be able to:

- Understand fundamental concepts of nanomaterials and the role of quantum effects at the nanoscale. Analyze the concept of quantum confinement and its effect on energy quantization in nanostructures, and relate it to the density of states (DOS) in bulk materials and low-dimensional systems
- Understand how surface-to-volume ratio and confinement regimes influence material behavior at the nanoscale
- Apply concepts like Fermi energy, Kubo gap, and excitons to real nanomaterial systems
- Derive and compare the density of states (DOS) for different nanostructures, including bulk materials (3D), quantum wells (2D), quantum wires (1D), and quantum dots (0D)
- Solve standard model problems involving free particles, and particles confined in 1D, 2D, and 3D boxes, and explain the significance of reduced dimensionality on energy spectra

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCNP225.1	3	2	3	2	1.5	2.5	1	2.5	1.5	1	**2.0**
MNTYCNP225.2	3	3	2	2.5	1.5	2	1.5	3	1	1.5	**2.1**
Average PLO	**3**	**2.5**	**2.5**	**2.25**	**1.5**	**2.25**	**1.25**	**2.75**	**1.25**	**1.25**	**2.05**

Unit-I (Lectures-15)

Nanomaterials and Quantum Confinement Effects: Introductory aspects: Overview of nanomaterials, definition of nanomaterials based on Bohr radius, de¬-Broglie wavelength, Exciton radius, Surface to volume ratio, Estimation of number of atoms in

nanostuctures, Excitons Frenkel and Mott-wannier Excitons, Confinement Regimes, Metallic and Semi conducting nanomaterials, Fermi Energy, Fermi Velocity, Kubo Gap, Drude Model, Charging Energy.

Unit-II (Lectures-15)

Nanostructures and Quantum Confinement: Classification of Nanomaterials Based on Dimensionality: Overview of nanostructures: 0D, 1D, 2D, and 3D systems. Standard Model Problems in Nanostructures Introduction to quantum confinement and boundary conditions. Model Problems: Free Particle, Particle in a 1D box , Particle in a 2D box , Particle in a 3D box , Energy quantization due to spatial confinement. Significance of reduced dimensionality in energy spectra. Density of States (DOS) in Different Systems DOS for Bulk Materials (3D) , DOS for Quantum Wells (2D) DOS for Quantum Wires (1D), DOS for Quantum Dots (0D), Comparison of DOS profiles across dimensionalities.

TEXT BOOKS / REFERENCES:

1. Introductory nanoscience Physical and Chemical Concepts by Masaru Kuno published by Garland Science, 2011.
2. Nanotechnology Principles and Practices by S K. Kulkarni published by Capital Publishing Company, 2011

MOLECULAR BASIS OF DISEASE	
Course Code: **MNTYCMD225**	Max. Marks: **50**
Contact Hours: **30**	External Examination: **36**
No. of credits: **02**	Internal Assessment: **14**

Course Learning Outcomes:

At the end of the course students will be able to:

- Build a foundational knowledge of human physiological systems, their structure, and function
- Explore disorder mechanisms to understand disease development and treatment design
- Understand key physiological systems critical for biomedical applications
- Connect disease pathogenesis to clinical signs and symptoms
- Analyze cellular/molecular disease mechanisms and current treatment innovations

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYDGM225.1	2.5	3	3	2	2.5	2	1.5	2.5	2	3	**2.4**
MNTYDGM225.2	3	3	3	2.5	2	1.5	1.5	3	1.5	3	**2.4**
Average PLO	**2.75**	**3**	**3**	**2.25**	**2.25**	**1.75**	**1.5**	**2.75**	**1.75**	**3**	**2.4**

Unit-I (Lectures-15)

Major human physiologic systems of current Interest for biomedical applications- for example, endocrine, cardiovascular, nervous, gastrointestinal, and respiratory systems.

Process of growth, differentiation and cell death and its molecular organisation in cellular homeostasis and diseases such as diabetes, cancer and neurodegenerative diseases. Introduction to disease pathogenesis, Pathological changes in diseases and the role of molecules and molecular changes in the pathological manifestation of disease.

Unit-II (Lectures-15)

Inflammation in normal and pathological state. Acute and chronic inflammation. Molecular mechanisms driving immunopathology in diseases like diabetes, autoimmune diseases, cancer and neurodegenerative diseases. Interdependence of molecular pathways in controlling homeostasis and disease pathology, targeting of molecular changes to reverse pathology and contribution of drugs; DNA modifications and mutations in diseases and its significance in the pathology associated with above diseases.

TEXT BOOKS/REFERENCES:

1. John E. Hall & Michael E. Hall. Guyton and Hall Textbook of Medical Physiology, 14th Edition (Elsevier), 2021
2. C. C Chatterjee. Human Physiology. (13th Edition), CBS publishers and distributors, 2020.
3. Robbins Basic Pathology, 9th edition, Kumar, Abbas, Fausto and Mitchell; Saunders, Publication, ISBN-13: 978-1437717815, 2013.
4. Selected research articles will be provided before each class.

PRINCIPLES AND TECHNIQUES OF GENE MANIPULATION		
Course Code: **MNTYCGM225**	Max. Marks:	**75**
Contact Hours: **45**	External Examination:	**54**
No. of credits: **03**	Internal Assessment:	**21**

Course Learning Outcomes:

At the end of the course students will be able to:

- Gain a comprehensive introduction to the principles and techniques of gene manipulation, essential for modern biotechnology and biomedical research
- Understand a range of techniques from basic DNA cloning to advanced genome editing and synthetic biology across diverse hosts
- Understand the key molecular tools and exploring their applications in medicine, agriculture, and industry.

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYDGM225.1	2	3	3	2.5	2	3	1	2.5	1	3	**2.3**
MNTYDGM225.2	1.5	3	3	3	2	3	1	3	1	3	**2.35**
MNTYDGM225.3	3	3	3	3	2	3	1	2.5	1	3	**2.45**
Average PLO	**2.16**	**3**	**3**	**2.83**	**2**	**3**	**1**	**2.66**	**1**	**3**	**2.36**

Unit-I (Lectures-15)

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

Unit-II (Lectures-15)

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

Unit III: (Lectures-15)

Techniques used in gene manipulation: Electrophoresis and Blotting Techniques: Basic principles & types of electrophoresis; Blotting techniques: Southern; Northern, Western; and their applications, ELISA. Polymerase chain reaction, Reverse Transcription PCR (RT- PCR), Real-Time PCR: Principle and methodology and applications. DNA microarray: Principle and methodology. Protein purification strategies. Purification GST fusion and Poly (His) tagged fusion proteins.

TEXTBOOKS/ REFERENCES:

1. Primrose SB, Twyman RM. Principles of Gene Manipulation and Genomics. Blackwell Publishing, 2006.
2. Green MR, Sambrook J. Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press, 2012.
3. Brown TA. Gene Cloning and DNA Analysis: An Introduction, Wiley-Blackwell, 2020.
4. Nicholl DST. An Introduction to Genetic Engineering, Cambridge University Press, 2023.

NANOSCIENCE AND TECHNOLOGY LAB-II

Course Code: **MNTYCNL225**	Max. Marks: **50**
Contact Hours: **60**	External Examination: **36**
No. of credits: **02**	Internal Assessment: **14**

Course Learning Outcomes:

Nanotechnology Lab course-II is designed for demonstrating the capabilities of nanotechnology tools, and how to use this technology for nano-scale fabrication and characterization and assess various properties at nanoscale.

- Students will be introduced to the practical knowledge, tools, hands on experimentation in the synthesis of nanomaterials (metal particles/polymeric nanoparticles/fibers/films etc.) by various methods- physical, chemical and biological routes, enzyme assays for biomolecules and molecular techniques for genetic engineering.

- Experiments include characterizations of nanomaterials by various techniques, and assessment of properties of fabricated nanomaterials-optical, enzyme activity assays, drug release analysis, environmental degradation studies.

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCNL225.1	3	3	2	2	2	1	2	3	2	3	2.3

List of Experiments*:

1. Microwave/Sonochemical synthesis of ZnO/TiO2 nanoparticles and their bandgap calculation, optical properties.
2. Solgel/Hydrothermal synthesis of ZnO/TiO2 nanomaterials, characterization, and optical properties.
3. Polymer-based nanoparticles to be synthesized using- emulsion-solvent evaporation, nanoprecipitation, ionic gelation, sol-gel, spray drying methods.
4. Synthesis of metal-based nanoparticles using- chemical methods to create gold, silver, cobalt, zinc oxide, titanium dioxide, or copper nanoparticles.
5. Green synthesis of metal and metal oxide nanomaterials using plants, microorganisms and fungi.
6. Antibacterial assay for assessment of antimicrobial activity of nanoparticles.
7. Enzyme assay (SGOT/SGPT) - determination of enzyme activity using kit-based/manual method.
8. Estimation of Blood glucose levels using glucose oxidase method.
9. Bacterial protein expression and affinity purification (GST and His tag).

Note: Lab exercises will be conducted as per the availability of required resources/ facilities

RESEARCH METHODOLOGYAND ETHICS		
Course Code: **MNTYDRM225**	Max. Marks:	**50**
Contact Hours: **30**	External Examination:	**36**
No. of credits: **02**	Internal Assessment:	**14**

Course Learning Outcomes:

At the end of the course students will be able to:

- Understand basic concepts of statistics and the need for statistical methods in research and data analysis methods
- Learn about the fundamental theory of probability and standard distributions and tests of significance used in statistical analysis
- Have a practical understanding of Descriptive Data Analysis, Sampling Theory, Biostatistical Inference, Testing of Hypotheses, Nonparametric Methods and Multivariate Regression Analysis
- Understand the basic concepts of ethics, plagiarism, data documentation in proper conduct of research communication skills

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYDRM225.1	3	2	1.5	3	1.5	1.5	1	1.5	2	3	2.0
MNTYDRM225.2	3	2	1.5	3	1.5	1.5	1	1.5	2	3	2.0
Average PLO	3	2	1.5	3	1.5	1.5	1	1.5	2	3	2.0

Unit-I (Lectures-15)

Principles of data documentation, protocol development, research questions and hypothesis driven research. Types of research studies

Introduction to Biostatistics -Need for Biostatistical Methods –Their uses and Misuses, Types of Variables, Data collection Methods, Population and Sample.

Descriptive Data Analysis Methods- Statistical Tables, Diagrams examples; Graphs, Measures of Central Tendencies and Dispersion, Correlation Analysis Methods, Linear Regression Analysis. Theory of probability, Standard Probability Distributions – Discrete distributions Binomial and Poisson, Univariate continuous distribution – Normal, and standard normal.

Unit-II (Lectures-15)

Tests of Significance of Statistical Hypotheses- Concept of Hypotheses –Null and Alternative hypotheses, Type I and Type II errors, Significance level, Critical region, Power of a test, P- value and its interpretation; Large and Small Sample Test – Normal test, Student's 't' test, Chi-square tests, Analysis of variance. Nonparametric methods- Non-parametric methods for estimation, Methods for tests of significance for the independent and correlated samples, Nonparametric Methods for more than two populations.

Plagiarism, regulatory principles, safety in research, ethics in nanomaterials-based research, ethics in clinical research, ethics in stem cell research, ethics in animal research, Case studies.

TEXT BOOKS/REFERENCES:

1. Statistical Techniques for data Analysis: J.K. Taylor & Cheryl C, 2004 Chapman & Hall (CRC).
2. Performing Data Analysis Using IBM SPSS: Lawrence S Meyers, 2015, John Wiley.
3. Research Ethics for Scientists, C. Neal Stewart Jr., Wiley-Backwell Publishers, 2011.
4. Ethics in Science, Ethical Misconduct in Scientific Research, John D'Angelo, CRC Press, 2012.
5. Kothari, Chakravanti Rajagopalachari. Research methodology: Methods and techniques. New Age International, 2004.

CONCEPTS OF DRUG DESIGN IN AYURVEDA	
Course Code: **MNTYDCD225**	Max. Marks: **50**
Contact Hours: **30**	External Examination: **36**
No. of credits: **02**	Internal Assessment: **14**

Course Learning Outcomes:

At the end of the course, students will be able to:

- Understand Ayurveda and the significance of medicinal plants in traditional Indian medicine, including principles of *Bhaishajya Kalpana* (Ayurvedic pharmaceutics)
- Learn Ayurvedic principles of drug design and the concepts of *Pathya-Apathya* (wholesome/unwholesome diets), applying them to daily life

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYDCD225.1	3	2	2	2	3	2	0.5	2	1.5	2	2.0
MNTYDCD225.2	2	3	2	2	3	2	0.5	2	1.5	2	2.0
Average PLO	2.5	2.5	2	2	3	2	0.5	2	1.5	2	2.0

Unit-I (Lectures-15)

Ayurveda in Indian Knowledge System, Medicinal plants and their use in traditional Indian Medicine. Introduction to Bhaishajya Kalpana (preparation of herbal drugs) and Rasashastra (preparation of metallic/mineral drugs). Paribhasha (technical terms) used in the context of Ayurvedic pharmaceutics. Importance of Compound formulations over Ekamoolika Prayoga (single drug therapy).

Unit-II (Lectures-15)

Knowledge about Pancha Vidha Kashaya Kalpana (basic pharmaceutical techniques). Swarasa (fresh juice), Kalka (paste), Kashaya (decoction), Phanta (hot infusion), Hima (cold infusion). Knowledge about important compound formulations. Taila/ghrta paka (medicated oils and ghees), Avaleha (confectioneries), Asava-Arishtas (fermented preparations), Vati-Gutika (pills, tablets), Bhasmas (calcined metals/minerals) and Rasaushadhis (metallic preparations).

TEXTBOOKS/REFERENCES:

1. Bhaishajya Kalpana Vijnanam by K Ramachandra Reddy
2. Bhaishjya Kalpana Vigyan by Siddhi Nandan Mishra
3. Rasa Shastra by Damodar Joshi
4. Rasa Ratna Samuchchaya by Damodar Joshi
5. Textbook of Rasashasra Dr. K Ramachandra Reddy
6. Ayurvedic formulary of India- Part I and II

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SEMESTER - III

NANOMATERIALS: PROPERTIES AND APPLICATIONS		
Course Code: **MNTYCNP325**	Max. Marks:	**75**
Contact Hours: **45**	External Examination:	**54**
No. of credits: **3**	Internal Assessment:	**21**

Course Learning Outcomes:

At the end of the course students will be able to:

- Gain a solid understanding of the unique properties and practical applications of nanoscale materials.

- Understand the optical, electronic, and magnetic behaviors of nanomaterials and their relevance to real-world uses.
- Develop expertise in nanomaterials and explore their applications across industries such as electronics, medicine, energy, and materials science.

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCNP325.1	3	3	3	2	2	3	1.5	3	1.5	3	2.5
MNTYCNP325.2	3	3	3	2.5	2	3	1	2.5	1.5	3	2.45
MNTYCNP325.3	3	3	3	2	2	3	1.5	2.5	1.5	2	2.35
Average PLO	3	3	3	2.16	2	3	1.33	2.66	1.5	2.66	2.43

Unit-I (Lectures-15)

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

Unit-II (Lectures-15)

Fundamental types of electronic materials and devices. Microelectronics and nanoscale electronics. Electron tunnelling and single electron transfer devices (SETs). Molecular wires and fabrication of nanoscale devices. Electrical conductivity in nanotubes, nanorods and nanocomposites. Photoconductivity of nanorods. Nanomagnetism and characteristics of Nanomagnetic materials and applications. Current status of spin based electronic devices.

Unit-III (Lectures-15)

Nano-Optics: Interaction of light with matter. The nano perspective. The surface plasmon – SPR and scattering - color generation from nanoparticles and nanostructures - applications of nanoplasmonics. Quantum dots - Optical properties related to quantum confinement and applications. Nanophotonics. Chemical Nanoengineering: Nanocatalysis and the nano perspective. Nanocomposites, fibers and different types of nanocomposite materials.

TEXT BOOKS/ REFERENCES:

1. Nanostructures and Nanomaterials, Synthesis, Properties, and Applications, G. Cao and Y. Wang. 2011
2. Hornyak, Dutta, Tibbals and Rao, Introduction to Nanoscience and Nanotechnology, New York, CRC press, 2008.
3. The Physics and Chemistry of Nanosolids by Frank J. Owens, Charles P. Poole Jr, Wiley-Interscience, 2008.

NANOMEDICINE AND DRUG DELIVERY

Course Code: **MNTYCND325**	Max. Marks:	**50**
Contact Hours: **30**	External Examination:	**36**
No. of credits: **02**	Internal Assessment:	**14**

Course Learning Outcomes:

At the end of the course students will be able to:

- Conceptualize the fundamental principles of nanomedicine, linking physicochemical properties of nanomaterials with administration routes and interactions with cells and tissues.
- Develop an understanding of active and passive targeting mechanisms and nanoparticle uptake in cells and tissues, with insights into drug release characteristics and mechanisms
- Know about the factors controlling pharmacokinetics of various drug formulations and benefits of nanodrug delivery
- Understand concepts of targeted drug delivery and importance of various types of advanced drug delivery systems through different routes based on nanotechnology

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCND325.1	3	3	3	2	2.5	3	2	2.5	1.5	3	**2.55**
MNTYCND325.2	3	3	3	2.5	2	3	2	2.5	1.5	3	**2.55**
Average PLO	**3**	**3**	**3**	**2.25**	**2.25**	**3**	**2**	**2.5**	**1.5**	**3**	**2.55**

Unit I: (Lectures-15)

Introduction to concepts of Nanomedicine, Controlled drug delivery, Advantages of nanotechnology in drug delivery- overcoming biological barriers, blood brain barrier, Design, fabrication, evaluation and applications of the nanosystems for drug and gene delivery- Polymeric Nanoparticles, Liposomes, Micelles, Solid Lipid Nanoparticles, Dendrimers, Implants and inserts, General characteristics of nanomaterials used in drug/gene delivery Drug encapsulation, Drug release, Effect of particle size/surface charge in drug delivery. Viral Vectors.

Unit II: (Lectures-15)

Nano Drug Delivery via Different Routes: Oral Drug Delivery – Concepts of Mucoadhesion; Intravenous Drug Delivery using nanoparticles – Concept of opsonisation; Transdermal, Intranasal and Ocular Drug Delivery using Nanoparticles, Strategies for Advanced Drug Delivery:-Prodrug and Bioconjugation; Concept of Drug Targeting, Site Specific Drug delivery utilizing Monoclonal Antibodies, Peptides and other biomolecules.

TEXT BOOKS/ REFERENCES:

1. Drug Delivery Systems, Pieter Stroeve and Morteza Mahmoudi, World Scientific Series: From Biomaterials towards Medical Devices, Vol I, 2018.
2. Nanoparticulates as Drug Carriers, Vladimir Torchillin, Imperial College Press, 2006.
3. Emerging nanotechnologies for diagnostics, drug delivery and medical devices, Kishore Cholkar, Abhirup Mandal, Ashim Mitra, Elsevier (2017).

PRINCIPLES OF REGENERATIVE MEDICINE & TISSUE ENGINEERING

Course Code: **MNTYCRM325**	Max. Marks:	**75**
Credit Hours: **45**	External Examination:	**54**
No. of credits: **03**	Internal Assessment:	**21**

Course Learning Outcomes:

At the end of the course students will be able to:

- Understand multidisciplinary concepts underpinning regenerative medicine & tissue engineering.
- Understand the developmental dynamics of cells during development to attain shape and form, the role of extracellular matrix in the repair of tissues.
- Gain knowledge and understanding on stem cells and their role in tissue growth, repair, regeneration and stem cell-based therapeutics in regenerative medicine.
- Understand bioengineering principles for design of engineered tissue constructs for regenerative medicine- ECM mimicking 2D & 3D Scaffolds, role of stem cells for developing engineered tissue constructs.

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCRM325.1	3	3	3	3	2	3	1	2.5	1.5	3	**2.5**
MNTYCRM325.2	3	3	3	3	2	3	1	2.5	1.5	3	**2.5**
MNTYCRM325.3	3	3	3	3	2	3	1	2.5	1.5	3	**2.5**
Average PLO	**3**	**3**	**3**	**3**	**2**	**3**	**1**	**2.5**	**1.5**	**3**	**2.5**

Unit-I (Lectures-15)

Current perspectives in Cell matrix and Regenerative Medicine, Developmental dynamics of cells: commitment, specification and lineage diversification during development, Cell-Extracellular matrix interactions in tissue development, Perspective of tissue maintenance and tissue regeneration- Role of extracellular matrix in the repair of tissues.

Unit-II (Lectures-15)

Stem cells and Progenitors; Types of Stem cells- embryonic stem cells, adult stem cells and induced pluripotent stem cells; Signaling pathways involved in self-renewal and differentiation of stem cells. Role of stem cells in tissue regenerations. Different Stages of Tissue Regeneration- Scar formation and Regeneration-; Hemostasis, Inflammation, Proliferation and Angiogenesis.

Unit-III (Lectures-15)

Bioengineering concepts for design of engineered tissue constructs for regenerative medicine: Triad of tissue engineering for regenerative medicine – ECM mimicking Scaffolds, Stem Cells & Growth factors. Biomaterials & scaffolds - polymer-based, protein-based and cellulose-based. Bioactive scaffolds, Electroactive scaffolds, Composite/hybrid scaffolds. 2D & 3D biomimetic scaffolds - Fibrous electrospun scaffolds, Hydrogels and Cryogels. 3D bioprinting- Cell encapsulation. Developing engineered tissue constructs- *In vitro* and *In vivo* evaluations.

TEXT BOOKS/ REFERENCES:

1. Principles of Regenerative Medicine, Anthony Atala, Robert Lanza James, Thomson Robert Nerem, 2nd Edition, Elsevier -2010
2. Ying Deng and Jordan Kuiper, Functional 3D Tissue Engineering Scaffolds: Materials, Technologies, and Applications (Woodhead Publishing Series in Biomaterials), 2017
3. Cato T. Laurencin, Lakshmi S. Nair. Nanotechnology and Regenerative Engineering: The Scaffold, Second Edition, CRC Press 2017

CANCER BIOLOGY – CELLULAR MECHANISMS AND TARGETED THERAPIES	
Course Code: **MNTYCCB325**	Max. Marks: **75**
Contact Hours: **45**	External Examination: **54**
No. of credits: **03**	Internal Assessment: **21**

Course Learning Outcomes:

At the end of the course students will be able to:

- Explore the intricate relationship between cellular signaling mechanisms and cancer biology, culminating in advanced nanotherapeutic approaches for cancer treatment.
- Study key signaling pathways including GPCR, RAS-MAPK, and PI3K, alongside the role of second messengers in cellular communication.
- Learn about cancer biology fundamentals, including oncogenes, tumor suppressor genes, and the hallmarks of cancer that characterize malignant transformation.
- Understand advanced cancer nanotherapeutics with emphasis on targeted drug delivery systems that exploit the EPR effect, receptor-based targeting strategies, and innovative physicochemical approaches.
- Develop a comprehensive understanding of how signaling dysregulation leads to cancer and how these molecular insights inform the development of next-generation therapeutic strategies.

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYDCB325.1	2	3	2	2	2	3	1	2.5	1.5	3	**2.2**
MNTYDCB325.2	2.5	3	2	2	2	3	1	2.5	1.5	3	**2.25**
MNTYDCB325.3	2	3	3	2.5	2	3	1	3	1.5	3	**2.4**
Average PLO	**2.16**	**3**	**2.33**	**2.16**	**2**	**3**	**1**	**2.66**	**1.5**	**3**	**2.28**

Unit-I (Lectures-15)

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

Unit-II (Lectures-15)

Cancer, causes of cancer, cellular oncogenes, Tumour suppressor genes, Properties of cancer cell, Hallmarks of cancer, cell immortalization and tumorigenesis, Insensitivity to

antigrowth signals; Evading Apoptosis (Anoikis), Angiogenesis, Tissue invasion and metastasis, Conventional chemotherapy drugs their mechanism and limitations.

Unit-III (Lectures-15)

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

TEXTBOOKS/REFERENCES:

1. Robert A. Weinberg. The Biology of Cancer, Garland Science, 2013.
2. Kumar and Srivastava. Nanomedicine for Cancer Therapy, Springer, 2017.
3. Stephen R. Grobmyer and Brij M. Moudgil. Cancer Nanotechnology: Methods and Protocols, Humana Press, 2010.
4. Hanahan and Weinberg: Hall marks of Cancer (Journal Reviews-2000, 2011 and 2022).

ENVIRONMENTAL, AGRICULTURAL AND FOOD NANOTECHNOLOGY

Course Code: **MNTYCEA325**	Max. Marks:	**75**
Contact Hours: **45**	External Examination:	**54**
No. of credits: **03**	Internal Assessment:	**21**

Course Learning Outcomes:

At the end of the course students will be able to:

- Explore nanotechnology for environmental sustainability: pollution control, water treatment, carbon capture, and nanosensor-driven pollutant detection.
- Examine nano-enabled agriculture (precision farming, nano-fertilizers/pesticides, nano-seed tech, soil remediation) and safety in nano-food systems.
- Learn about nano-innovations in food processing (encapsulation, emulsions) and packaging (antimicrobial coatings, enhanced barriers, nano-biosensors for safety).

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYDEA325.1	3	2	3	3	2	2	1.5	2.5	1.5	1	**2.15**
MNTYDEA325.2	2.5	2	3	3	2.5	2	2	2.5	1	1	**2.15**
MNTYDEA325.3	2	3	3	3	2	2	1.5	2.5	1	2	**2.2**
Average PLO	**2.5**	**2.33**	**3**	**3**	**2.16**	**2**	**1.66**	**2.5**	**1.16**	**1.33**	**2.16**

Unit-I (Lectures-15)

Environmental Nanotechnology - Definitions and types of pollution, sources and control using traditional methods to overcome. Types of nanomaterials used in environmental applications, Surface modification and functionalization of nanomaterials, Different heavy metal removal using nanomaterials, Nanostructured TiO_2 particles, film and

membrane-based materials for photocatalysts for water treatment, Dendrimer-enhanced filtration. Plasma-assisted technology for water treatment, and Nanomaterials for carbon capture and storage. Nanosensors in the detection of pollutants.

Unit-II (Lectures-15)

Fundamentals of nanotechnology in agriculture: different routes of delivery of nanomaterials to plants, Types of nanomaterials used in farming, Precision farming, Insecticides using nanotechnology, Nano-fertilizers for enhanced nutrient delivery, Nano-pesticides for targeted pest control, Application of Nanotechnology in pest management, Soil remediation using nanomaterials. Plant and microbe-derived constituents such as green nanotechnology, Nano fertilizers: Nano urea and mixed fertilizers, Nano fertigation – geophonic and hydroponic routes, Nano seed technology, Health Concerns, Safety Regulations.

Unit-III (Lectures-15)

Food Processing: Nano-encapsulation of nutrients, flavors, and preservatives and nano-emulsions. Food Packaging: Nanoparticles and nanocoatings for improved barrier properties, shelf-life extension, and antimicrobial protection. Food Safety: Nanobiosensors for detecting pathogens and contaminants, and nano-based antimicrobial agents. Nutrient Delivery: Nano-encapsulation for improving nutrient bioavailability and absorption. Challenges and considerations from bench to field.

TEXTBOOKS/REFERENCES:

1. Environmental Nanotechnology: Volume 1. (2018). – by Eric Lichtfouse, Nandita Dasgupta, Shivendu Ranjan, Germany: Springer International Publishing.
2. Nanotechnology in the Agri-Food Sector: Implications for the Future. (2011). by- Arnout Fischer, Frans Kampers, Lynn J. Frewer, Willem Norde, Germany: Wiley.
3. Nanotechnology for Water Treatment and Purification (2014). – by Allen Apblett, Anming Hu, Germany: Springer International Publishing.
4. Applications of Nanobiotechnology. (2020). – by Margarita Stoytcheva, Roumen Zlatev, United Kingdom: IntechOpen.
5. Nanotechnology for Food, Agriculture, and Environment (2020). - by Thangadurai, D. . Switzerland: Springer International Publishing.
6. Handbook of Food Nanotechnology: Applications and Approaches. (2020). - By Seid Mahdi Jafari Netherlands: Academic Press.

NANOSCIENCE AND TECHNOLOGY LAB-III SCIENTIFIC VISIT TO INDUSTRY/ RESEARCH INSTITUTES	
Course Code: **MNTYCNL325**	Max. Marks: **100**
Contact Hours: **120**	External Examination: **70**
No. of credits: **04**	Internal Assessment: **30**

Course Learning Outcomes:

Nanotechnology Lab course-III is designed for-

- Demonstrating the capabilities of nanotechnology tools, and how to use this technology

for applications in various areas-nanotechnology, nanomedicine, therapeutics, regenerative medicine and environment engineering & food technology (No. of credits: **02**).

- Research tour/short trainings in reputed Industry/ Institute for a period of two-week, which will result in a report and an oral presentation by* students before an external examiner* (No. of credits: **02**).

- **Note: In case of any unforeseen situation if the above-mentioned scientific tour/training is not possible, this part of the course will also be considered as lab work*.*

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCNP325.1	3	3	2	2	2	2	2	3	3	3	**2.5**

List of Experiments:

1. Microemulsion/Polyol route for the preparation of nanomaterials/Fabrication of metal oxide thin film coatings using spin coating technique and characterizations thereof.
2. Encapsulation of drug in nanoparticles and the estimation of drug release kinetics from the fabricated nanoparticles.
3. Fabrications of fibrous scaffolds/ films by electrospinning/ solvent casting methods and characterizations thereof.
4. Case Studies in Tissue regeneration & Bioengineering - Ectoderm derived tissues (Nerve tissue), Endoderm derived tissues (Liver) and Mesoderm (Bone/ Cartilage).
5. Peptide mediated delivery in cancer cells-Demonstration of CendR transport (Endocytosis).
6. Surface modification of hydrophobic and hydrophilic surfaces for filtration/applications.
7. Fabrication of coatings to increase shelf life of agriculture/food products.

NANOSENSORS & DEVICES		
Course Code: **MNTYDNS325**	Max. Marks:	**50**
Contact Hours: **30**	External Examination:	**36**
No. of credits: **02**	Internal Assessment:	**14**

Course Learning Outcomes:

At the end of the course students will be able to:

- Have an understanding of foundational nanosensor principles integrating nanotechnology, electronics, and materials science
- Have a comprehensive knowledge of nanosensor design, fabrication, and application, including the role of advanced nanomaterials in optimizing sensor functionality
- Understand semiconductor nanodevices (single-electron transistors, FinFETs) for quantum mechanical operations and low-power circuits.

- Learn about sensor systems, including Lab-on-a-chip, self-powered sensors.
- Have the ability to quantify critical sensor metrics (sensitivity, LOD) to optimize biosensors

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCNS325.1	3	3	3	3	2	3	1	2.5	1	3	2.45
MNTYCNS325.2	3	3	3	2	2	3	1	3	1	3	2.4
Average PLO	3	3	3	2.5	2	3	1	2.75	1	3	2.42

Unit-I (Lectures-15)

Introduction- Moore's Law, Nanomaterials for Sensing, Nanodevice fabrication: Photolithography, E-beam, DLP. Photoresist - Positive, Negative. Nanofabrication limitations. Semiconductor Nanodevices/transistors: Single-Electron Devices, Carbonnanotube (CNT) and Graphene FET, FinFET.

Unit-II (Lectures-15)

Fundamentals of sensors, Key performance metrics: Sensitivity, selectivity, response time, limit of detection (LOD). biosensor, micro fluids, MEMS and NEMS. Packaging and characterization of sensors. Lab-on-a-chip, neuromorphic nanosensors, Self-powered sensors: Piezoelectric/triboelectric nanogenerators. Nanotweezers, nano-cutting tools, Integration of sensor with actuators and electronic circuitry, Nanobots in medicine.

TEXT BOOKS/ REFERENCES:

- J. M. Martínez-Duart, R.J. Martín-Palma and F. Agulló-Rueda, Nanotechnology for Microelectronics and Optoelectronics, Elsevier B.V, 2006.
- Nanomaterials for Biosensors, Cs. Kumar, Wiley – VCH, 2007.
- Smart Biosensor Technology, G.K. Knoff, A.S. Bassi, CRC Press, 2006.
- SE Lyshevski, "MEMS and NEMS: Systems, Devices, and Structures" 2002.
- Handbook of Semiconductor Nanostructures and Nanodevices, Vol 1-5-A. A. Balandin K. L. Wang, American Scientific Publishers, 2005.

PERSONALITY DEVELOPMENT AND COMMUNICATION SKILLS		
Course Code: **MNTYDPC325**	Max. Marks:	**50**
Contact Hours: **30**	External Examination:	**36**
No. of credits: **02**	Internal Assessment:	**14**

Course Learning Outcomes:

At the end of the course, students will be able to:

- Analyze core elements of personality development, including self-assessment (SWOT), attitudes, motivation, and interpersonal behaviors (aggressive/submissive/assertive).

- Demonstrate effective communication skills through verbal/n-verbal techniques, active listening, public speaking, and professional written communication (emails/reports).
- Apply strategies for personal and professional effectiveness, including teamwork, time management, stress/anger management, and work-life balance.

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYDPC325.1	2	1.5	1	1	1.5	2	3	2.5	3	3	2.05
MNTYDPC325.2	2	1	1.5	1	1.5	2	3	2.5	3	3	2.05
Average PLO	2	1.25	1.25	1	1.5	2	3	2.5	3	3	2.05

Unit-I (Lectures-15)

Introduction to Personality Development; Definition and importance. Elements of personality. The concept of success and failure and factors responsible. Self-assessment & SWOT analysis. Attitude: positive and negative. Motivation and self-esteem. Interpersonal Relationships –aggressive, submissive and assertive behaviors.

Unit-II (Lectures-15)

Communication Skills: Verbal and non-verbal communication, Active listening, public speaking & presentation skills. Written communication (emails, reports). Body language and tone modulation. Teamwork and collaboration, Time management & work ethics. Stress & anger management. work-life balance. Gratitude and positive thinking.

TEXTBOOKS/REFERENCES:

1. Hurlock, E.B (2006). Personality Development, 28th Reprint. New Delhi: Tata McGraw Hill.
2. Stephen P. Robbins and Timothy A. Judge (2014), Organizational Behavior 16th Edition: Prentice Hall.
3. Pravesh Kumar. All about Self- Motivation. New Delhi. Goodwill Publishing House. 2005.

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SEMESTER-IV

RESEARCH PROJECT: PROJECT PRESENTATION AND DISSERTATION	
Course Code: **MNTYCRP425**	Max. Marks: **500**
Contact Hours: **600**	**External Examination/ Evaluation** will be done by Two External subject Experts for the following components as per following breakup: 1. Research based Dissertation: 350 marks 2. Project Presentation: 100 marks 3. Viva Voce: 50 marks
No. of credits: **20**	

Course Learning Outcomes:

Students shall choose a lab where they would like to pursue their dissertation either within the department or in any reputed research Institution. The supervisor assigned shall help the students to read papers in the areas of interest of the lab and help them select a topic for their project. If a student chooses a supervisor outside the department, he/she will be assigned a mentor/co-supervisor from the department who shall mentor & provide training during the course of project. At the end of the course students are expected to:

- Develop skills in literature surveying, research design, and proposal drafting
- Gain hands-on experience in executing and documenting a research project
- Strengthen data analysis, technical writing, and dissertation preparation abilities
- Enhance presentation/defense skills through committee evaluation and feedback
- Build critical thinking and problem-solving via real-world research challenges
- Foster collaborative and mentorship-driven academic/professional growth

UNIT-WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	Average
MNTYCRP425.1	3	3	3	2	2	1.5	3	3	3	3	2.65

Contents & components of the Internship:

1. **Research topic Selection for the Project**: Assigned Supervisor/Mentor will train students in the following during the course of internship: **1)** Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources. **2)** With the help of the supervisor, students should be able to discuss the research questions, goals, approach, methodology, data collection, etc., students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a synoptic format for dissertation.

2. **Research based Dissertation** (*Laboratory Research work*): Students will submit a Research based Dissertation. The dissertation shall be based on original work carried out by the students during the internship period of one full semester in the laboratory.

3. **Presentation & Viva-voce:** At the end of their project, Students will have to make a detailed open oral presentation about the work carried out for the topic of their project before a departmental faculty members and external examiner. They should be able to explain the novelty and importance of their research topic/work. Students will explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.

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