Nanotechnology Masters Programme

Curricula & Syllabus

Course Description and Outcomes

MSNT101-CR	Essentials of Nanoscience & Nanotechnology

Description: The Essentials of Nanoscience & Nanotechnology" provides a comprehensive introduction to the field of nanoscience and nanotechnology, covering the basic concepts, terminology, and principles that underlie these disciplines. This could include explanations of quantum effects, nanoscale materials, and unique phenomena that emerge at the nanoscale. This course enables the students to have proper understanding of more complex concepts involved in the field of Nanoscience and Nanotechnology.

Outcomes: Upon completing the course, students will have the basic knowledge of nanoscience and nanotechnology and will understand different types of nanomaterials, such as nanoparticles, nanotubes, and nanolayers. Also, through a general understanding of Nanoscale Phenomena, Students should gain a deep understanding of the unique physical, chemical, and biological properties that emerge at the nanoscale. They will learn how these properties differ from those at the macroscopic scale and how they can be harnessed for various applications. The course also emphasizes the interdisciplinary nature of nanoscience and nanotechnology, encouraging students to integrate knowledge from various fields, such as physics, chemistry, biology, and engineering.

MSNT102-CR	Concepts in Solid State Physics

Description: Solid-state physics objectives encompass comprehending the atomic and molecular bonding leading to diverse crystal structures and identifying inherent defects. The field also delves into materials' electronic structures, lattice vibrations, thermal characteristics, and optical and dielectric properties. Researchers aim to uncover fundamental principles governing solid behavior, all while fostering education and outreach to inspire the next generation.

Outcomes: Students can expect to gain advanced knowledge of the behavior of solids, which includes crystal structures, electronic properties, and unique phenomena. This expertise equips them with problem-solving skills applicable across scientific and technical fields. Graduates often find opportunities in academia, research, or industries related to electronics, materials, and energy technologies. They may contribute to groundbreaking research, technological innovations, and even entrepreneurial ventures

MSNT103-CR	Cell & Molecular Biology

Description: This course has specific objectives: to equip students with a foundational understanding of biochemical principles, including biomolecule classification, monosaccharides, amino acids, enzymes, nucleic acids, and lipid diversity. It aims to illuminate metabolic processes' intricacies in prokaryotic and eukaryotic organisms and their relevance to health and disease. Additionally, the course explores Molecular Biology aspects such as DNA replication, Transcription, Translation, genetic code, and post-translational modifications. It culminates by imparting knowledge about Cell Biology, encompassing cell structures, membranes, transport, extracellular matrices, and cell division regulation. These objectives collectively empower students to comprehend biological intricacies, contributing confidently to the field of life sciences.

Outcomes: Upon completion of this comprehensive course, students will emerge with a robust comprehension of essential biochemical concepts, enabling them to navigate complex biological processes and cellular functions adeptly. They will develop the skills to effectively classify biomolecules and discern their biochemical roles. Through in-depth exploration, students will gain expertise in monosaccharides and polysaccharides, amino acids' properties and structural organization, enzymatic functionalities, nucleic acid structures, DNA's genetic significance, lipid diversity, and metabolic pathways. Additionally, students will grasp Molecular Biology intricacies including DNA processes, genetic code, translation regulation, and post-translational modifications. The course will culminate in a profound understanding of Cell Biology, encompassing cell structures, membranes, transport mechanisms, extracellular matrices, and the intricacies of cell division regulation. This comprehensive knowledge empowers students to comprehend and contribute to the fascinating realms of life sciences with confidence**.**

MSNT104-CR	Elements of Spectroscopy

Description: The primary goal of this course is to foster a comprehensive grasp of the interactions between matter and light, as well as to elucidate the fundamental principles that govern different types of molecular transitions and their subsequent outcomes. Students will be familiarized with the basics of different spectroscopic techniques and applications in structure determination of molecules.

Outcomes: The main outcomes of the course are centered around equipping students with a comprehensive understanding of various spectroscopic techniques and enabling them to effectively apply this knowledge to interpret experimental results, both at the Masters and research levels. The students will acquire knowledge of electronic spectroscopy, the modes of excitation and its applications**,** basics of IR spectroscopy and vibrational frequencies of different functional groups, NMR spectroscopy and chemical shift values, which will help them in structural elucidation of different molecules.

MSNT105-DCE	Carbon Nanostructures and Porous Materials

Description: The study of Carbon Nanostructures aims to understand their unique properties and applications, including carbon nanotubes, graphene, nanodiamonds, and fullerenes. Objectives include exploring synthesis techniques, mechanical and electrical properties, and composite materials. Similarly, the investigation of Porous Materials focuses on their nanoscale voids. Goals include studying synthesis, adsorption, catalysis, and applications in purification and drug delivery. These studies provide insights into advanced materials for technological progress.

Outcomes: By the end of this course, students will be able to understand and have knowledge about Carbon-based nanomaterials, their fundamental properties identify and explain the applications of Carbon Nanotubes, Fullerenes, Graphene, and Carbon Nanofoam in various fields. Furthermore, students will attain a comprehensive grasp of micro- and mesoporous materials, nanoporous substances, such as zeolites, molecular sieves, aerogels, and Metal-Organic Frameworks (MOFs). They will also showcase their knowledge of these advanced materials and their prospective technological uses.

MSNT106-DCE	Genetic Engineering

Description: The course "Recombinant DNA Technology Tools and Applications" aims to provide students with a comprehensive understanding of the fundamental tools and techniques in genetic engineering. It focuses on mastering essential concepts such as restriction endonucleases, DNA ligases, and plasmid vectors. Students will delve into cloning procedures, explore various expression systems, and gain practical skills in protein expression and purification. The course also introduces innovative methods like yeast hybrid systems and fluorescent proteins for advanced applications.

Outcomes: Upon completing the course, students will emerge with a proficient understanding of recombinant DNA technology. They will possess the skills to manipulate DNA fragments, create recombinant plasmids, and transform bacterial cells. Students will be adept at expressing and purifying proteins using different systems and techniques, ranging from bacterial to mammalian expression. Additionally, they will have gained insights into innovative tools for studying protein-protein interactions and cellular imaging. Overall, graduates will be well-prepared to contribute effectively to biotechnology research and applications.

MSNT107 DCE	Introduction to Mathematics-I

Description: To provide information and skills with regard to calculus and differential equations.

Outcomes: After the completion the course, students shall be able to deal with problems arising in Nanoscience, like optimization and dynamics of materials.

MSNT108DCE	Advanced Techniques

Description: The course aims to equip students with a comprehensive understanding of advanced techniques in recombinant DNA technology. By exploring principles and applications of electrophoresis, blotting techniques, enzyme-linked immunosorbent assay (ELISA), polymerase chain reaction (PCR), reverse transcription PCR (RT-PCR), real-time PCR, and DNA microarray, students will gain a solid foundation in cutting-edge molecular biology methodologies.

Outcomes: Upon completing the course, students will possess a proficiency in a range of advanced molecular biology techniques. They will be adept at biomolecule separation through electrophoresis, adeptly employing blotting techniques for molecular analysis. Students will confidently apply ELISA for detecting and quantifying molecules, and they will be skilled in PCR and its variants for DNA amplification and gene expression analysis. Furthermore, students will grasp the principles of DNA microarray technology for high-throughput gene expression profiling. Armed with this expertise, graduates will be well-prepared to contribute effectively to modern molecular biology research and biotechnological applications.

MSNT201-CR	Synthesis of Nanomaterials: Physical and Chemical Approaches

Description: The course aims to provide students with a comprehensive toolkit of knowledge and skills related to nanomaterial synthesis. By studying this course, students will be familiar with various synthesis methods and capable of critically analyzing and selecting appropriate methods for specific applications. Additionally, they will understand the importance of tailoring nanomaterial properties to meet the needs of diverse fields, such as tissue engineering.

Outcomes: By the end of this course, students will understand growth and nucleation in nanomaterial synthesis. Different top-down and bottom-up approaches for nanomaterial synthesis will be identified. A deep understanding of various methods for nanomaterial synthesis, including Inert gas condensation, Arc discharge, Laser ablation, Ball milling, Reduction, Solvothermal/hydrothermal route, Sonochemical synthesis, and more, will be achieved. Students can analyze the electrospinning method's parameters influencing nanofiber morphology, porosity, and characteristics. The understanding of different classes of nanoparticles and exploring the synthesis of organic nanoparticles, nanofibers, and nanocomposite materials for tissue engineering applications will be acquired.

MSNT202-CR	Characterization Methods of Nanomaterials

Description: Nanotechnology often requires specialized techniques to visualize and manipulate materials at the nanoscale. This course gives a comprehensive overview of various characterization techniques used in material science like XRD, Raman, IR, XPS, PL, Zeta Potential, etc. Furthermore, the course extensively covers advanced techniques tailored for the

examination of nanomaterials, including but not limited to SEM, TEM, AFM, and STM, providing students with comprehensive insights.

Outcomes: Upon completing this course, students will possess a comprehensive theoretical understanding of various essential scientific techniques, enabling them to proficiently operate instruments and analyse resulting data. These skills will equip them to excel in their scientific pursuits, contribute to research advancements, and effectively communicate their findings, while also instilling a strong sense of ethical responsibility in their work.

MSNT203CR	**Human Physiology & Disease**

Description: The course encompasses a set of focused objectives aimed at providing students with a comprehensive understanding of various essential topics. Firstly, the course aims to illuminate the intricate interplay of molecules, cells, tissues, and organ systems within human health and disease. Through the lens of physiology, students will grasp the underlying mechanisms driving the functioning of living organisms and their components. The course also seeks to instil a solid grasp of key physiological themes such as homeostasis, regulatory mechanisms, structure-function relationships, and compartmentation across diverse organ systems. Ultimately, the course intends to equip students with a profound ability to predict perturbations' impacts, integrate diverse physiological concepts, and comprehend the collaborative nature of different systems to maintain overall balance.

Outcomes: Upon completing the course, students will emerge with a diverse skill set and an enriched understanding of crucial physiological and immunological aspects. They will be adept at comprehending the pivotal role of the immune system in defence against pathogens and its implications for diseases like autoimmunity, allergy, and cancer. Furthermore, students will demonstrate a strong grasp of cell signalling’s influence on cellular behaviours in both health and disease contexts, navigating the complexities of ligands, receptors, and intracellular communication pathways. Additionally, students will possess a holistic understanding of cancer biology, spanning from its fundamental concepts to intricate molecular mechanisms and therapeutic approaches. Overall, graduates will be well-prepared to contribute significantly to the fields of physiology, immunology, cell signalling, and cancer biology, thereby advancing scientific research and applications.

MSNT204CR	**Concepts in Nanoscale Physics**

Description: The main objectives of this course in condensed matter physics and nanoscience encompass understanding and exploring the electronic properties, quantum phenomena, and transport behavior in one-dimensional and nanostructured systems. This includes quantization effects, spectroscopy of singularities, interactions, and thermal properties, with the aim of advancing fundamental knowledge and enabling innovative applications in materials science and nanotechnology.

Outcomes: Completing this comprehensive course in condensed matter physics and nanoscience equips students with a deep understanding of electronic properties in various materials, from 1D systems to nanocrystals. This knowledge enables advanced research contributions, particularly in nanotechnology, materials science, and quantum technologies. Graduates are also prepared for real-world challenges, including novel materials development and sustainability efforts, fostering essential skills for addressing global issues and shaping the future of science and technology.

MSNT205-CR	**Introduction to Electronics**

Description: The objectives of "Introduction to Electronics" course encompass providing students with a comprehensive understanding of fundamental electronic principles, including voltage, current, and circuit laws, while also enabling them to identify and work with electronic components. Additionally, the course aims to equip students with the skills necessary for analyzing and troubleshooting basic electronic circuits, introducing them to operational amplifiers and digital electronics concepts. Practical hands-on experience is emphasized through laboratory exercises, fostering critical thinking and problem-solving abilities. Furthermore, students are made aware of the ethical considerations associated with electronics, ensuring responsible practices in this field. Overall, this course seeks to lay a strong foundation in electronics, preparing students for further study and practical applications in diverse technological domains.

Outcomes: Upon completing this course, students will acquire a comprehensive understanding of semiconductor fundamentals, including their processing, diverse types, and wide-ranging applications. They will also grasp the operational principles and applications of diodes, as well as gain insight into Bipolar Junction Transistors (BJTs) and Metal Oxide Semiconductor Field Effect Transistors (MOSFETs). Furthermore, students will develop a strong comprehension of the inner workings of contemporary digital Integrated Circuits (ICs). This knowledge equips them with a solid foundation in semiconductor technology and its practical applications in electronics and modern technology.

MSNT206 DCE	**Nanotechnology Laboratory Course-I: MSNT 206DCE**

Description and Outcomes: Upon completion of this course, students will possess a well-rounded skill set in various laboratory techniques encompassing nanomaterial synthesis, molecular biology, and cell culture. They will be adept at utilizing laboratory equipment and adhering to safety protocols. Students will also possess the capability to design and execute experiments, analyze data, and interpret results critically. With hands-on experience in nanomaterial synthesis and advanced molecular techniques, they will be prepared to contribute to research, development, and innovation in fields spanning nanotechnology, materials science, biotechnology, and molecular biology.

MSNT207-DCE	Introduction to Mathematics-II

Description: To teach various methods and techniques of Laplace transform and Fourier series.

Outcomes: After the completion of this course, the students shall be able to use these techniques in problems arising in nanostructure analysis, control systems and characterization of Nanomaterials.

MSNT208DCE	Bionanoscience & Therapeutics

Description: The course "Bionanoscience and Therapeutics" aims to provide students with a foundational understanding of biological processes, ranging from the nanoscale to cellular complexities. It offers insights into the construction and functioning of cellular machinery, bridging the gap between fundamental insights and practical applications in drug design and targeted nanomedicine. Students will also gain knowledge of nanoparticle applications and their synthesis using biological systems. In the "Pharmaceutical Chemistry and Drug Development" course, the objectives are to equip students with a comprehensive comprehension of pharmaceutical sciences. This includes understanding conventional drug administration methods, exploring chemical modifications for enhanced efficacy and safety, delving into innovative drug discovery techniques, and comprehending drug metabolism processes. Students will also grasp essential concepts in drug design and its practical application.

Outcomes: Upon completing the courses, students will possess a strong foundation in Bionanoscience and therapeutics, enabling them to understand biological processes at various scales and their potential applications. They will gain insights into nanoparticle applications and their synthesis. Additionally, students will emerge from the pharmaceutical chemistry and drug development course with a comprehensive grasp of essential pharmaceutical science aspects. They will have the ability to optimize drug delivery, understand chemical modifications' impact on therapeutics, explore innovative drug discovery methods, and appreciate the significance of drug metabolism in efficacy and elimination. Overall, graduates will be well-equipped to contribute effectively to the fields of Bionanoscience, therapeutics, pharmaceutical chemistry, and drug development, further advancing research and practical applications in these domains.

MSNT301-CR	Nanomaterials: Properties & Applications

Description: This course's primary goal is to impart a profound understanding of the distinctive properties and practical applications offered by nanoscale materials. It covers a broad spectrum of topics, including micro- and nanoelectronics, single electron transfer devices (SETs), and nanomagnetic materials, enabling students to appreciate the real-world implications of nanomaterials. Additionally, the course delves into luminescent materials and their role in display technology, further expanding students' knowledge of nanomaterial applications. By the end of the course, students will be well-versed in the remarkable world of nanoscale materials and their diverse applications, positioning them to contribute to cutting-edge advancements in science and technology.

Outcomes: This course is oriented towards novel and unique properties exhibited by the nanoscale materials and the applications of these unique materials across different industries, such as electronics, medicine, energy, and materials science. This course makes the students to understand as to how nanotechnology is transforming these industries and enabling novel technologies. Also, some of the latest research and breakthroughs in nanotechnology are discussed to motivate the students to have insights into the current state of the field.

MSNT302-CR	**Nanoelectronics: Nanodevices and Nanosensors**

Description and Outcomes: This course is designed to provide students with a well-rounded comprehension of nanotechnology fundamentals and their applications. By the end of the course, students will not only have a solid grasp of the core principles of nanotechnology but also the ability to identify and address the limitations of conventional MOS devices when scaled down to nanoscale. They will be well-versed in alternative nanoscale devices, recognizing their potential for nanoelectronics applications. Furthermore, students will gain insights into macro and nanoscale sensors, exploring their operational principles and diverse real-world applications. Additionally, the course covers opto-electronic devices, enabling students to understand how these devices operate and their significance in modern electronics and telecommunications. In essence, this course equips students with a comprehensive toolkit of knowledge and skills in nanotechnology, setting the stage for them to engage in cutting-edge research and innovation in this rapidly evolving field.

MSNT303-CR	**Nanomedicine-I: Applications in Therapeutics & Diagnostics**

Description: This course aims to provide students with a comprehensive understanding of the transformative role of nanotechnology in healthcare, specifically focusing on medicine advancement and targeted therapy delivery. It covers various nanosized drug delivery systems, biomaterial interactions, and the toxicological aspects of nanoparticles. The course delves into clinical biomaterials, overcoming biological barriers, and the principles of nanoscale drug delivery systems. Additionally, it explores the biomedical applications and toxicological considerations of nanoparticles, equipping students with a holistic perspective on nanotechnology's impact on healthcare.

Outcomes: Upon completing the course, students will possess a robust comprehension of the intricate relationship between nanotechnology and healthcare. They will grasp the nuances of nanosized drug delivery systems, clinical biomaterials, and their interactions with biological systems. Students will understand the principles of targeted therapy delivery and the potential toxicological implications of nanoparticles. Furthermore, graduates will emerge well-equipped to address challenges in nanomedicine and contribute to innovative advancements in medicine, targeted therapy, and disease treatment using cutting-edge nanotechnological approaches.

MSNT305DCE	Nanotechnology Laboratory Course-II

Description and 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. Students will be introduced to the practical knowledge, tools, hands on experimentation in the synthesis of nanomaterials (particles/fibers/films etc. by various methods-physical, chemical and biological methods. Synthesis of Nanomaterial using biological methods (bacteria/fungi/plants), polymeric biodegradable nanoparticles and encapsulation of drug in nanoparticles will be covered in this course. Together with Lab course-I, this course will equip students with knowledge and skill to carry out their internship projects in Semester-IV, well poised to contribute to the forefront of nanotechnology and scientific research.

MSNT306DCE	Nanomedicine - II: Biomedicine, Current Status & Challenges

Description and Outcomes: This course includes Stem Cell Biology and Regenerative Medicine that has a clinical focus, incorporating basic aspects of Cell Therapy and Tissue Engineering. Students have the opportunity to learn about new, up to date technologies that are applicable to modern therapeutic approaches such as: stem cell-based cell therapy, tissue engineering, functionalized scaffolds and biomaterials. Furthermore, students will be introduced to recent advancement in understanding of nano-bio interface and its significance in design of effective nanotherapeutics. Finally, this course will equip students with knowledge of approved drug therapies based on nanotechnology, nano-based therapeutic candidates in clinical trials, nano-toxicity issues and regulatory approach to nanomedicines. Ultimately, students will emerge with a nuanced understanding of applications of nanotechnology in Stem Cell based therapeutics, Regenerative Medicine, poised to contribute to the forefront of and nanomedicine and scientific research.

MSNT307DCE	Environmental Nanotechnology

Description: This course aims to provide the students with the understanding of role of carbon nanomaterials in sensor applications for water monitoring and contaminant detection. The uses of TiO2 as photocatalysts, dendrimers in water purification using plasma-assisted technology and iron oxide nanomaterials in water remediation. Other pair of this course aims for potential of nanotechnology in agriculture, including precision farming, smart delivery systems, nanofertilizers, food industry; including smart packaging and safety considerations. This course aim to provide students with a comprehensive understanding of carbon nanosensors, research methodology, and applications of nanotechnology in environmental and other fields.

Outcomes: The course covers a wide array of applications of nanotechnology in various sectors, highlighting both theoretical knowledge and practical applications. The course outcome will equip students with a thorough understanding of nanomaterials, their synthesis, and their real-world implications in fields, especially in environmental monitoring, water purification, agriculture, and the food industry.

MSNT401-CR	**Research Proposal Writing**
MSNT402-CR	**Project- Research Based**
MSNT403-DCE	**Project Presentations**
MSNT405-DCE	**Viva Voce**

In 4th Semester, students are assigned a faculty member as supervisor/mentor for full semester research project-based internship. Students are taught how to do literature survey and write a research proposal. Students under the guidance of their supervisors/mentors carry out research work for a dissertation that they present and defend and appear in viva-voce before a committee of examiners including an external examiner.

MSNT404-DCE	**Laboratory Bio-Safety Course**

Studying a Laboratory Bio-Safety Course can lead to a range of outcomes that are essential for maintaining safety and ensuring proper practices in laboratory environments, particularly those involving biological materials. Some potential outcomes include, Enhanced Knowledge of Bio-Safety Practices, Improved Laboratory Safety, Compliance with Regulations, Prevention of Biohazardous Contamination, Effective Use of Personal Protective Equipment (PPE), Waste Management, Emergency Response Preparedness, Public Health Protection etc. Ultimately, studying a Laboratory Bio-Safety Course equips individuals with the knowledge and skills necessary to work safely and responsibly, minimizing risks and contributing to the overall well-being of laboratory personnel, the environment, and public health.