Syllabus of 4 + 1 Year Integrated UG and PG Programme

w. e. f 2024-25 Academic Year

GRADUATE SCHOOL

Mahatma Gandhi University

P. D. Hills P O

Kottayam, Kerala

www.gs.mgu.ac.in

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Schools offering Majors

SL.No	School/Centre
1	School of Bio Sciences
2	School of Chemical Sciences
3	School of Computer Sciences
4	School of Environmental Sciences
5	School of Gandhian Thought and Development Studies
6	School of International Relations and Politics
7	School of Pure and Applied Physics
8	School of Social Sciences

Sl. No.	Major	Intake
SCIENCE		
1	Bio Sciences	6**
2	Chemistry	6
3	Computer Science	6
4	Environmental Science	6
5	Physics	6
SOCIAL SCIENCES		
1	Development Studies	5
2	Gandhian Studies	5
3	History	10
4	International Relations and Politics	10

Majors offered and Intake *1 seat shall be sanctioned over and above the intake in each major in the 3rd semester for students who opt for a change of major after two semesters.

**Progression to PG Shall be based on the specialization selected by students as Biochemistry (2 seats) Biotechnology (2 seats) and Microbiology (2 seats) based on merit.

Schools offering Minors/MDCs/AECs/VACs/SECs

SL.No	School/Centre
1	School of Artificial Intelligence And Robotics
2	School of Behavioural Sciences
3	School of Biosciences
4	School of Chemical Sciences
5	School of Computer Sciences
6	School of Data Analytics
7	School of Energy Materials
8	School of Environmental Sciences
9	School of Food Science And Technology
10	School of Gandhian Thought And Development Studies
11	School of Gender Studies
12	School of Indian Legal Thought
13	School of International Relations And Politics
14	School of Letters
15	School of Mathematics And Statistics
16	School of Nanoscience And Nano Technology
17	School of Pedagogical Sciences
18	School of Polymer Science And Technology
19	School of Pure And Applied Physics
20	School of Social Sciences
21	School of Tourism Studies
22	International and Inter University Centre for Nanoscience and Nanotechnology
23	K N Raj School of Economics

Scheme for 4 + 1 Integrated UG and PG Programme
Graduate School
Mahatma Gandhi University
International and Inter University Centre for Nanoscience and Nanotechnology

Course Code	Title	Credits	Hours per Week		Level	Type
			Theory	Practicals		
SEMESTER I						
MG1MDCUCN101	Introduction Nanotechnology in Medicine and Healthcare	3	3	0	"	MDC
MG1MDCUCN102	Nanotechnology In Sustainable Polymers	3	3	0	"	MDC
SEMESTER II						
MG2MDCUCN101	Introduction To Polymer Nanotechnology Applications	3	3	0	"	MDC
MG2MDCUCN102	Nanotechnology In Plastics Packaging	3	3	0	"	MDC
SEMESTER III						
MG3MDCUCN201	Polymers For Nanomedicine	3	3	0	"	MDC
MG3MDCUCN202	Impact Of Micro and Nano Plastics on The Ecosystem	3	3	0	"	MDC
MG3VACUCN201	Polymer Adhesives and Coatings	3	3	0	"	VAC
MG3VACUCN202	Nano Revolution in Green Tyre	3	3	0	"	VAC
SEMESTER IV						
MG4SECUCN201	Fiber Reinforced Polymer (FRP) Composites	3	3	0	"	SEC
MG4SECUCN202	AI In Polymer Manufacturing and	3	3	0	"	SEC

	Characterization					
MG4VACUCN201	Nanostructures from Natural Origin	3	3	0	“	VAC
MG4VACUCN202	Fundamentals Of Nanostructured Polymer Foams	3	3	0	“	VAC
SEMESTER V						
MG5SECUCN301	Biodegradable Polymers for Drug Delivery and Tissue Engineering	3	3	0	“	SEC
MG5SECUCN302	Non-Destructive Testing of Polymer Composites	3	3	0	“	SEC
MG5VACUCN301	Natural Fiber Reinforced Polymer Composites (NFRPCs): Product Designs and Their Applications	3	3	0	“	VAC
MG5VACUCN302	Intellectual Property and Patenting in The Polymer Sector	3	3	0	“	VAC
SEMESTER VI						
MG6SECUCN301	Polymer-Based 4D Printing for Advanced Manufacturing	3	3	0	“	SEC
MG6SECUCN303	Business Planning for Polymer Entrepreneurs	3	3	0	“	SEC
Total Credits						

*Only for 4-Years Honours Students
**Only for students who opt for theory courses instead of Research Project

Note: General foundations courses shall be offered by different schools. Students can flexibly choose the courses across disciplines.

Level	Foundation	Intermediate	Highe	Advance	PG

	(100-199	(200-299)	r (300-399)	d (400-499)	Level (500-599)

Type	Major	Minor	MDC	SEC	VAC	AEC

	MAHATMA GANDHI UNIVERSITY **Graduate School**
	4 + 1 Integrated UG and PG Programme

School	International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	**Nanotechnology in Medicine and Healthcare**		
Course Type	MDC		
Course Level	100-199		
Course Code	MG1MDCUCN101		
Course Overview	This course provides an understanding of applications of nanotechnology in medical field. Students will gain knowledge about the fundamentals of nanotechnology and its various applications in medical field. They will be able to develop critical thinking skills to analyse and develop new strategies based on nanotechnology to solve medical problems.		
Semester	1	**Credit**	3
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	45 (L) + 15(T)	NA	
Pre-requisite	Knowledge of basic chemistry and biology		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Gain a foundational understanding of nanotechnology principles and their applications in healthcare.	R, U, An	
2	Understand various applications of nanotechnology in medical diagnostics and	R, U, A, E	

	therapeutics.		
3	Students will critically evaluate the safety, ethical considerations, and future directions of nanotechnology in healthcare.	U, An, C, S	

*(Learning Domains: Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)

COURSE CONTENT

Module 1	**Hours**	**CO No**
Fundamentals of Nanotechnology in Healthcare Introduction to Nanotechnology; Nanomaterials for Biomedical Applications; Nanotechnology-based Drug Delivery Systems	15	1
Module 2	**Hours**	**CO No**
Applications of Nanotechnology in Medicine Nanotechnology in Medical Imaging; Therapeutic Applications of Nanotechnology; Nanotechnology in Disease Prevention and Control	15	2
Module 3	**Hours**	**CO No**
Safety, Ethics, and Future Directions Nanotoxicology and Safety Assessment; Emerging Trends and Future Directions; Case Studies and Applications	15	3

Mode of Transaction	**Classroom Activities:** • Interactive lectures • Group discussions and problem-solving exercises • Quizzes and Assignments **Field activities:** **Lab based activities:**
Mode of Assessment	• Internal Exams • Semester Exam • Assignments and Seminars

Learning Resources

1. Amna, T., & Hassan, M. S. (Eds.). (2021). Innovative Approaches for Nanobiotechnology in Healthcare Systems. IGI Global.
2. Bhowmick, T. K., Gayen, K., & Maity, S. K. (Eds.). (2024). Nanobiotechnology: Applications of Nanomaterials in Biotechnology, Medicine and Healthcare. CRC Press.
3. Online resources – Online polymer introductory courses from websites like Khan Academy, National Institute of Open Schooling (NIOS), MOOC, and NPTEL offer free learning modules on polymers
4. Invited lectures by visiting academic and industrial scientists. Held regularly on Wednesday afternoon and Saturday morning throughout the academic year.

Relevance of Learning the Course/ Employability of the Course
Studying nanotechnology in medicine and healthcare holds immense promise for transforming diagnostics, treatment strategies, and patient outcomes. It represents a frontier where interdisciplinary research combining nanoscience, biology, and medicine can lead to innovative solutions for challenging medical issues. The field of nanotechnology in medicine and healthcare offers a wide range of job opportunities across various sectors. Some key job roles and areas where nanotechnology is applied include: • Research and Development (R&D) • Clinical Applications • Business and Commercialization • Academic and Education

	MAHATMA GANDHI UNIVERSITY **Graduate School**
	4 + 1 Integrated UG and PG Programme

School	International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	**Nanotechnology In Sustainable Polymers**		
Course Type	MDC		
Course Level	100-199		
Course Code	MG1MDCUCN102		
Course Overview	This course provides a comprehensive introduction to the exciting and rapidly evolving field of nanotechnology as applied to sustainable polymer science. Students will gain a solid foundation in the principles of nanotechnology, understanding the synthesis, characterization, and properties of nanomaterials. The course will delve into the integration of nanomaterials into polymer matrices to develop advanced materials with enhanced sustainability, performance, and functionality.		
Semester	1	**Credit**	3
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	45 (L) + 15(T)	NA	
Pre-requisite	All Discipline		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	To understand the fundamental concepts of nanotechnology and polymer science.	R, U	
2	To explore the synthesis and characterization techniques of various nanomaterials.	R, U, C	
3	To learn about the different methods of incorporating nanomaterials into polymer matrices.	U, A	
4	To evaluate the impact of nanomaterials on the properties and performance of polymers.	R, U, An	
5	To assess the environmental and economic sustainability of polymer nanocomposites	R, U, An, E	

*(Learning Domains: Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E) , Create (C), Skill (S))

COURSE CONTENT

Module 1	**Hours**	**CO No**
Introduction to Nanotechnology and Polymers Overview of Nanotechnology and Its Significance, Basic Concepts of Polymer Science, Types of Polymers and their Properties, Challenges in Conventional Polymer-Based Materials.	15	1
Module 2	**Hours**	**CO No**
Nanomaterials and Polymer Nanocomposites Classification of Nanomaterials (Carbon-Based, Metal, Ceramic, Etc.), Synthesis Methods (Top-Down, Bottom-Up), Characterization Techniques (Microscopy, Spectroscopy, etc.), Properties of Nanomaterials (Optical, Electrical, Magnetic, Etc.), Polymer Nanocomposites,	15	2,3,4

Types of Polymer Nanocomposites (Reinforcing, Intercalated, Exfoliated), Processing Techniques for Nanocomposites, Influence of Nanomaterials on Polymer Properties (Mechanical, Thermal, Electrical, Etc.).		
Module 3	**Hours**	**CO No**
Sustainable Nanotechnology in Polymers Green Synthesis of Nanomaterials, Bio-Based Nanomaterials and Their Applications, Degradable and Compostable Nanocomposites, Life Cycle Assessment, Economic and Environmental Impact of Nanotechnology, Functional Nanopolymers (Conductive, Magnetic, Optical), Sustainable Self-Healing Polymers.	15	5

Mode of Transaction	**Classroom activities:** • Interactive lectures • Group discussions and problem-solving exercises • Quizzes and Assignments **Lab based activities:**
Mode of Assessment	• Assignments • Internal examination • End-semester examination

Learning Resources

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Relevance of Learning the Course/ Employability of the Course
This course highly relevant to addressing global challenges like climate change. It equips students with skills to innovate in materials science, creating environmentally friendly solutions. Graduates are sought after in diverse sectors such as materials engineering, chemical industry, automotive, aerospace, energy, and environmental consulting. This interdisciplinary field offers excellent career prospects and opportunities to contribute to a sustainable future.

	MAHATMA GANDHI UNIVERSITY **Graduate School**
	4 + 1 Integrated UG and PG Programme

School	International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	**Polymer Nanomaterials for Energy Applications**		
Course Type	MDC		
Course Level	100-199		
Course Code	MG2MDCUCN101		
Course Overview	This course delves into the exciting and rapidly growing field of polymer nanomaterials for energy applications. Students will explore the synthesis, characterization, and properties of polymer-based nanostructures and their role in enhancing energy conversion, storage, and utilization technologies.		
Semester	2	**Credit**	3
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	45 (L) + 15(T)	NA	
Pre-requisite	Understanding of Basic Chemistry		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.

	*Upon completion of this course, students will be able to**;***		
1	To understand the fundamental principles of polymer science and nanotechnology.		
2	To explore the synthesis and characterization techniques of polymer-based nanomaterials for energy applications.		
3	To evaluate the properties and performance of polymer nanomaterials in energy devices.		
4	To investigate the latest advancements and challenges in the field of polymer nanomaterials for energy.		
5	To develop critical thinking and problem-solving skills for addressing energy-related issues using polymer nanotechnology.		
6			

*(Learning Domains: Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)

COURSE CONTENT

Module 1	**Hours**	**CO No**
Introduction to Energy and Nanotechnology Energy Crisis, Sustainable Energy Sources, Basics of Polymer Science, Introduction to Nanotechnology and its Principles, Characterization Techniques for Nanomaterials (SEM, TEM, AFM, XRD, FTIR, Etc.)		
Module 2	**Hours**	
Polymer Nanomaterials for Energy Conversion Organic Solar Cells: Principles, Materials, Device Architecture, Polymer-Based Dye-Sensitized Solar Cells, Polymer-Based Perovskite Solar Cells, Polymer-Based Thermoelectric Materials and Devices.		
Module 3	**Hours**	

Polymer Nanomaterials for Energy Storage and Harvesting Lithium-ion Batteries: Components, Working Principle, And Challenges, Polymer Electrolytes and Solid-State Batteries, Sodium-Ion Batteries and Polymer-Based Electrodes, Supercapacitors: Principles, Materials, and Applications, Piezoelectric and Pyroelectric Polymers, Polymer-Based Nanogenerators, Energy Harvesting from Ambient Sources (Solar, Wind, Vibration).		

Mode of Transaction	**Classroom activities:** • Interactive lectures • Group discussions and problem-solving exercises • Quizzes and Assignments **Lab based activities:**
Mode of Assessment	• Assignments • Internal examination • End-semester examination

Learning Resources

- Textbooks
    1. Polymer Nanocomposites: Synthesis, Characterization, and Applications by Yiu-Wing Mai and Zhong-Zhen Yu
    2. Polymer Nanomaterials for Energy and Environmental Applications by Niranjan Karak
    3. Nanostructured Polymer Blends and Composites in Textiles by Visakh P. M., Long Yu
- Research articles
- Review articles

Relevance of Learning the Course/ Employability of the Course
This course equips students with cutting-edge knowledge in sustainable and renewable energy technologies, making them highly relevant in today's green energy landscape. This multidisciplinary course prepares students for careers in nanotechnology, materials science, and energy sectors, enhancing their employability in roles focused on energy storage, conversion, and generation. Proficiency in these areas meets the increasing demand for innovative solutions in the energy industry, positioning graduates at the forefront of technological

advancements.

	MAHATMA GANDHI UNIVERSITY **Graduate School**
	4 + 1 Integrated UG and PG Programme

School	International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	**Nanotechnology In Plastics Packaging**		
Course Type	MDC		
Course Level	100-199		
Course Code	MG2MDCUCN102		
Course Overview	Nanotechnology, the manipulation of matter at the nanoscale, has revolutionized various industries, including plastics and packaging. By incorporating nanomaterials into plastics, manufacturers can create packaging materials with enhanced properties, such as increased strength, barrier properties, antimicrobial activity, and sustainability. This course explores the principles, applications, and challenges of nanotechnology in plastics packaging.		
Semester	2	**Credit**	3
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	45 (L) + 15(T)	NA	
Pre-requisite	All Discipline		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Understand the fundamentals of nanotechnology and its applications in polymer science.	U, R	
2	Explore the various types of nanomaterials used in plastic packaging and the methods of incorporating nanomaterials into plastic packaging.	U, R, An	
3	Evaluate the impact of nanotechnology on the properties and performance of plastic packaging, its application and assess the environmental and health implications of nanotechnology in packaging.	An, E	
4	Develop critical thinking and problem-solving skills related to nanotechnology in packaging.	An, E	

*(Learning Domains: Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E) , Create (C), Skill (S))

COURSE CONTENT

Module 1	**Hours**	**CO No**
Introduction to Nanotechnology and Plastics Packaging Basics Of Nanotechnology and its Potential in Packaging, Overview of the Plastics Packaging Industry, Challenges in Conventional Plastic Packaging	**15**	**1**
Module 2	**Hours**	
Nanomaterials for Packaging Applications Types of Nanomaterials (Nanoparticles, Nanotubes, Nanofibers, Etc.), Properties and Characteristics of Nanomaterials, Synthesis and Characterization Techniques, Polymer Matrix and Nanomaterial	**15**	**2**

Interactions, Processing Techniques for Nanocomposites, Mechanical, Thermal, and Barrier Properties of Nanocomposites		
Module 3	**Hours**	
Functional Packaging with Nanotechnology Antimicrobial Packaging Using Nanomaterials, Intelligent Packaging with Nanosensors, Active Packaging with Nanomaterials for Controlled Release, Biodegradable and Compostable Nanocomposites, Life Cycle Assessment of Nanomaterial-Based Packaging. Applications in Food, Pharmaceutical, and Medical Packaging.	**15**	**3,4**

Mode of Transaction	**Classroom activities:** • Interactive lectures • Group discussions and problem-solving exercises • Quizzes and Assignments **Lab based activities:**
Mode of Assessment	• Assignments • Internal examination • End-semester examination

Learning Resources

1. Textbooks
    - Nanotechnology in Food Packaging by Vimal Katiyar, Vikas Yadav, and Saurabh Nanavati
    - Polymer Nanocomposites for Food Packaging Applications by Jasim Ahmed, Brijesh K. Tiwari, Syed H. Imam, and M.A. Rao
    - Nanotechnology-Enhanced Food Packaging by Jorge Barros-Velázquez
2. Journal Articles
3. Review Articles

Relevance of Learning the Course/ Employability of the Course
This is a highly relevant course due to the growing demand for sustainable and functional packaging solutions. Graduates of this course will possess a unique skill set, making them highly employable in the packaging industry, nanotechnology research, and related sectors. They will be equipped to develop

innovative packaging materials with enhanced properties, contributing to a more sustainable future.

	MAHATMA GANDHI UNIVERSITY **Graduate School**
	4 + 1 Integrated UG and PG Programme

School	International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	**Polymers for Nanomedicine**		
Course Type	MDC		
Course Level	200-299		
Course Code	MG3MDCUCN201		
Course Overview	This course introduces the fundamentals of polymers and their applications in nanomedicine. It covers the synthesis, properties, and applications of biopolymers, polymer nanocarriers, and polymer-based therapeutic systems. The emphasis is on exploring how polymers are used for drug delivery, diagnostics, and tissue engineering.		
Semester	3	**Credit**	3
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	45 (L) + 15(T)	NA	
Pre-requisite	Basic understanding of chemistry and biology		

COURSE OUTCOMES (CO)

	Expected Course Outcome		

CO No.	*Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Understand the fundamental concepts of polymers and their relevance in nanomedicine.	**R, U, A**	
2	Identify and describe various polymeric materials used in medical applications.	**U, A, An**	
3	Explain the role of polymers in drug delivery systems and their mechanisms.	**U, A, E**	
4	Analyze the properties and functionality of polymeric nanocarriers for therapeutic and diagnostic applications.	**U, An, C**	

*(Learning Domains: Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)

COURSE CONTENT

Module 1	**Hours**	**CO No**
Fundamentals of Polymer Chemistry and Nanotechnology Introduction to polymers: Types, structure, and properties, Basics of nanomedicine and its significance in healthcare, Biopolymers and synthetic polymers in medicine Polymer synthesis techniques (basic overview): Emulsion polymerization, solution polymerization, Polymer characterization: Molecular weight, thermal properties, and mechanical properties	**10**	**1**
Module 2	**Hours**	
Polymeric Nanocarriers for Drug Delivery Polymeric nanoparticles, micelles, and dendrimers, Mechanisms of drug encapsulation and release, Surface modification of polymeric carriers for targeted drug delivery Case studies: Polyethylene glycol (PEG), polylactic acid (PLA), and chitosan-based systems, Advantages and limitations of polymer-based drug delivery systems	**14**	**2, 3**
Module 3	**Hours**	

Applications and Advances in Polymer-Based Nanomedicine Polymers in tissue engineering and regenerative medicine, Stimuli-responsive polymers (pH-sensitive, temperature-sensitive, etc.). Polymers in diagnostic imaging (MRI contrast agents, fluorescent polymers). Biodegradability and biocompatibility considerations, Challenges and future trends in polymers for nanomedicine	**15**	**4**

Mode of Transaction	**Classroom activities:** • Interactive lectures • Group discussions and problem-solving exercises • Quizzes and Assignments • Guest lectures by experts in the field **Lab based activities:**
Mode of Assessment	• Assignments • Internal examination • End-semester examination

Learning Resources

1. Introduction to Polymers by Robert J. Young
2. Nanomaterials for Biomedical Applications by A.K. Gaharwar
3. Polymeric Biomaterials by S.L. Cooper

Relevance of Learning the Course/ Employability of the Course
This course is highly relevant due to the burgeoning field of nanomedicine and the crucial role of polymers in its advancements. Nanomedicine is a rapidly evolving interdisciplinary field with immense potential to revolutionize healthcare. Understanding the principles of polymer chemistry and their application in nanomedicine is essential for researchers and professionals in this domain. Career Opportunities: Research & Development: Pharmaceutical companies, Biotechnology firms Academic institutions, Government research laboratories Industry: Medical device companies, Nanomaterials manufacturing, Biomedical Engineering

By learning about polymers for nanomedicine, students will be well-equipped to contribute to this exciting and rapidly growing field and significantly impact human health and well-being.

	MAHATMA GANDHI UNIVERSITY **Graduate School**
	4 + 1 Integrated UG and PG Programme

School	International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	**Impact of Micro and Nano Plastics on the Ecosystem**		
Course Type	MDC		
Course Level	200-299		
Course Code	MG3MDCUCN202		
Course Overview	This course explores the emerging and significant environmental threat posed by micro and nano plastics. As plastic pollution continues to accumulate in ecosystems worldwide, the focus is shifting from visible debris to micro and nano-sized particles that are not easily detected but are having profound effects on wildlife, ecosystems, and human health. This course will provide an in-depth understanding of the sources, characteristics, behavior, and consequences of micro and nano plastics in various environmental contexts.		
Semester	3	**Credit**	3
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	45 (L) + 15(T)	NA	

Pre-requisite	Understanding of Basic Chemistry

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	To understand the fundamentals plastic pollution and generation of micro-nano plastics.	R, U	
2	Explore the types and different paramenter of micro – nano plastics	R,U	
3	Evaluate environmental interactions, distribution and transfer among various spheres,	R,U,A,E,	
4	To Handling latest analytical methods for Micro-Nanoplastics.	R,U,A,An,S	
5	Mitigation and management of micro-nano plastics	R, U, An	
6	Gaps in our current understanding are identified, and bottle necks in current technologies and analytical techniques are enlisted and presented as future challenges.	R,U	

*(Learning Domains: Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)

COURSE CONTENT

Module 1	Hours	CO No
Introduction to Microplastics Introduction to micro and nanoplastics, Origin, growth and fate of micro and nanoplastic production, Types and classification of micro and nano plastics, parameters of classification (Origin, size, shape, composition, color, toxicity.	**15**	**1,2**

Module 2	Hours	
Interaction of micro and nano plastics in every sphere of Earth, (Atmosphere, Land/soil, aquatic) and food chain. Scant Attention on the Micro and nanoplastics, impacts of physical and chemical properties, Attention of Micro and nano plastics in the atmosphere, characteristics and fate of atmospheric microplastics, Modes of Entry into the Human Physiological System, Translocation into the Vital Organs.	**15**	**3**
Module 3	**Hours**	
Analytical Methods, Mitigation, Management, and the Challenges Methods for identification of micro and nano plastics - theory and practice, mitigation and management methods, gaps and challenges.	**15**	**4,5,6**

Mode of Transaction	**Classroom activities:** • Interactive lectures • Group discussions and problem-solving exercises • Quizzes and Assignments **Lab based activities:**
Mode of Assessment	• Assignments • Internal examination • End-semester examination

Learning Resources

- **Sewell, M. A., & Korley, J. P. (2022).** *Microplastics and nanoplastics in freshwater ecosystems: Impact on biota and the environment*. *Science of the Total Environment*, 740, 140394.

Relevance of Learning the Course/ Employability of the Course
This course is highly relevant to addressing plastic pollution by the generation of micro and nano plastics. Learning about micro and nanoplastics is essential for addressing current global environmental challenges and opens a wide range of career opportunities both in research and industry.

	MAHATMA GANDHI UNIVERSITY **Graduate School**
	4 + 1 Integrated UG and PG Programme

School	International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	Polymer Adhesives and Coatings		
Course Type	VAC		
Course Level	200-299		
Course Code	MG3VACUCN201		
Course Overview	This course covers the fundamentals of polymer adhesives and coatings, including their composition, properties, application methods, and performance characteristics. Emphasis is placed on the molecular design of polymers, the mechanisms behind adhesion, and how coatings are applied to various substrates to protect, decorate, or enhance surface properties		
Semester	3	**Credit**	3
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	40 (L) + 10(T)	10	
Pre-requisite	Basic understanding of chemistry		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Understand the Fundamentals of Adhesion and Coating	R, U, A	
2	Analyze the Composition and Types of Adhesives	U, A, An	
3	Analyze the factors affecting adhesive performance including surface preparation, environmental conditions, and substrate compatibility	U, A, E	
4	Understand the Applications of Adhesives and Coatings	U, A, C	
5	Explore Emerging Trends and Innovations	U, A, S	

*(Learning Domains: Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)

COURSE CONTENT

Module 1	Hours	CO No
Introduction to Adhesion Definition of adhesion and cohesive forces, Types of adhesive bonds: mechanical, physical, and chemical, Composition of Polymer Adhesives Structure and composition of adhesive materials: Monomers, Polymers, Curing agents, Types of polymer adhesives, Factors Affecting Adhesive Performance	10	1,2
Module 2	**Hours**	
Fundamentals of Coating Coating processes: Spray, Dip-coating, Electrodeposition, Types of coatings: Organic coatings, Inorganic coatings, Role of	12	1,3,4

coating in enhancing durability, corrosion resistance, and appearance **Interfacial Phenomena**-Surface energy and its role in adhesion, Contact angle measurement and wetting behaviour, Surface preparation techniques: Cleaning, Priming, Roughening		
Module 3	**Hours**	
Applications of Adhesives and Coatings Automotive industry: Structural bonding, sealing, and coatings, Aerospace: Lightweight bonding, corrosion resistance coatings, **Emerging Trends and Innovations** Smart adhesives and coatings: Self-healing, reversible adhesion, Environmental sustainability: Green adhesives, eco-friendly coatings, Advances in nanotechnology: Nano-coatings, nano-fillers for enhanced performance **<u>Lab section</u>** Preparation of polymer-based adhesives using different polymers Methods of applying coatings Testing Adhesive Properties	**10+8**	**2,4,5**

Mode of Transaction	**Classroom activities:** • Interactive lectures • Group discussions and problem-solving exercises • Quizzes and Assignments **Lab based activities:** • Preparation • Testing

Mode of Assessment	• Assignments • Internal examination • End-semester examination

Learning Resources

- Handbook of Adhesion" by Irving I. Schwartz
- Adhesion and Adhesives" by D. S. M. K. L. Thomas
- "Polymer Coatings: Technology and Applications" by P. G. McHugh

Relevance of Learning the Course/ Employability of the Course
Learning the Polymer Adhesives and Coatings course positions individuals at the forefront of a rapidly evolving field with ample career opportunities in diverse industries. It offers a combination of scientific knowledge and practical applications, making it a valuable skill set for future employability in both established and emerging sectors.

	MAHATMA GANDHI UNIVERSITY **Graduate School**
	4 + 1 Integrated UG and PG Programme

School	International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	Nano Revolution in Green Tyre		
Course Type	VAC		
Course Level	200-299		
Course Code	MG3VACUCN202		
Course Overview	This course explores the integration of nanotechnology in the tyre industry, focusing on how nanomaterials are transforming the production of tyres, enhancing their performance, and contributing to sustainability. Emphasis will be placed on green technologies, innovative materials, and the environmental benefits of modern tyre manufacturing techniques. The course will also discuss future trends, innovations, and the role of nanotechnology in improving tyre safety, efficiency, and performance.		
Semester	3	**Credit**	3

Total Student Learning Time	Instructional hours for theory	Instructional hours for practical/lab work/field work
	35 (L) + 15(T)	10
Pre-requisite	All discipline	

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Understanding of Nanotechnology in Tyre Manufacturing	R,U	
2	Innovative Materials and Their Impact on Tyre Performance	R,U,E	
3	Application of Green Technologies in Tyre Industry	A,E,R	
4	Environmental Benefits and Sustainability	U,R,E,A	
5	Future Trends and Innovations in Tyre Technology	A,An,,S,R	

*(Learning Domains: Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)

COURSE CONTENT

Module 1	Hours	CO No
Introduction to Nanotechnology and Tyre Industry, Nanomaterials and Their Role in Tyre Manufacturing, Types of nanomaterials used in tyre production, Mechanisms of nanomaterials in improving tyre performance, Environmental Benefits and Sustainability of Green Tyres, Balancing tyre performance with environmental impact, Regulatory Framework and Standards for Green Tyres.	**10**	
Module 2	**Hours**	

Green Technologies in Tyre Manufacturing, Sustainable raw materials, Impact of nanomaterials on tyre durability, wear resistance, and fuel efficiency, Application of nanotechnology in improving traction, safety, and comfort, Case studies of advanced tyre designs	**12**	
Module 3	**Hours**	
Environmental regulations impacting the tyre industry (e.g., REACH, ISO 14001), Standards for green tyres: Certification, testing, and labelling, Global trends in sustainable tyre practices Future Trends in Tyre Technology, Smart tyres: Sensors, monitoring, and predictive maintenance, Emerging nanomaterials for future tyre technologies **Lab wok** • Synthesis of silica nanoparticles and their incorporation into rubber matrices • Testing and characterization of synthesized nanoparticles and their dispersion in rubber compounds. • Mixing rubber with nanomaterials and observing compound rheology and viscosity	**22**	

Mode of Transaction	**Classroom activities:** • Interactive lectures • Group discussions and problem-solving exercises • Quizzes and Assignments **Lab based activities:** • Synthesize rubber compounds • Characterization
Mode of Assessment	• Assignments • Internal examination • End-semester examination

Learning Resources

- Green Tires: A Guide to the Environmental Impact of Tires and Sustainable Solutions" by Andrew J. M.
- Advances in Green Technology" edited by Vishnu S. and Alok S.

Relevance of Learning the Course/ Employability of the Course
This course is highly relevant as it provides cutting-edge knowledge that blends nanotechnology with environmental sustainability, equipping individuals with the skills to drive innovation in the tyre industry and contribute to global sustainability efforts.

	MAHATMA GANDHI UNIVERSITY **Graduate School**
	4 + 1 Integrated UG and PG Programme

School	International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	**Fiber Reinforced Polymer (FRP) Composites**		
Course Type	SEC		
Course Level	200-299		
Course Code	MG4SECUCN201		
Course Overview	This course offers an in-depth understanding of Fiber Reinforced Polymer (FRP) Composites, focusing on their properties, manufacturing processes, structural design, and real-world applications. FRP composites, which combine polymer matrices with reinforcing fibers have revolutionized various industries due to their superior strength-to-weight ratio, durability, and versatility. Students will explore the mechanics of FRP materials, learn about the different fiber and resin types, understand composite manufacturing techniques, and delve into the performance characteristics of FRP composites in structural, aerospace, automotive, and civil engineering applications.		
Semester	4	**Credit**	3
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	

	45 (L) + 15(T)	NA
Pre-requisite	Understanding of Basic Chemistry	

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Understand the Fundamentals of FRP Composites	U	
2	Analyze the Mechanical Properties of FRP Composites	An,U,R	
3	Understand Manufacturing Techniques for FRP Composites	U,R,S	
4	Evaluate the Performance of FRP Composites in Various Applications	U,R,A,	
5	Conduct Experimental Testing and Characterization	C,S,R,A	
6	Stay Informed on Current Trends and Innovations in FRP Composites	E,R,A	

*(Learning Domains: Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)

COURSE CONTENT

Module 1	Hours	CO No
Introduction to FRP Composites Overview of composite materials, Historical development of FRP composites, Components of FRP composites: fibers and matrix, Properties of different reinforcement materials. Fiber geometry: unidirectional, woven, chopped strand mats. Fiber-matrix interaction, Types of matrix materials: thermosets vs. thermoplastics	**12**	
Module 2	**Hours**	
FRP Composite Manufacturing Techniques	**14**	

Hand lay-up process, Filament winding, Resin transfer molding (RTM) and vacuum infusion, Compression molding, Additive manufacturing for FRPs, Mechanical Properties of FRP Composites, Structural Design of FRP Composites		
Module 3	**Hours**	
Applications of FRP Composites, Environmental and Sustainability Aspects of FRP Composites, Challenges and Future Trends in FRP Composites, Case Studies and Industry Applications	**15**	

Mode of Transaction	**Classroom activities:** • Interactive lectures • Hands-on laboratory exercises. • Industry guest speakers and case study analysis. • Group projects and presentations • Quizzes and Assignments **Lab based activities:**
Mode of Assessment	• Assignments • Internal examination • End-semester examination

Learning Resources

- Fiber-Reinforced Composites: Materials, Manufacturing, and Design" by P.K. Mallick
- Handbook of Composite Materials" by L. K. T. Gupta
- Fundamentals of Composites Materials" by V. R. K. Murthy

Relevance of Learning the Course/ Employability of the Course
The growing demand for advanced materials in various industries makes a course on Fiber Reinforced Polymer Composites highly valuable. Graduates of this course will have diverse employability opportunities, contributing to cutting-edge developments in material science, engineering, and sustainable technologies.

	MAHATMA GANDHI UNIVERSITY **Graduate School**
	4 + 1 Integrated UG and PG Programme

School	International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	AI In Polymer Manufacturing and Characterization		
Course Type	SEC		
Course Level	200-299		
Course Code	MG4SECUCN202		
Course Overview	The course would likely cover the integration of artificial intelligence (AI) technologies into the polymer manufacturing process and the techniques used for characterizing polymer materials. The objective would be to enable students or professionals to understand how AI can be applied to improve the efficiency, precision, and innovation in polymer production and analysis		
Semester	4	**Credit**	3
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	

	45 (L) + 15(T)	NA
Pre-requisite	A solid background in chemistry, physics, mathematics, and basic programming skills	

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Apply AI in polymer discovery and manufacturing	R, U, A	
2	Skills to predict polymer properties using AI models	S	
3	Optimize manufacturing for efficiency and quality with AI	An, E	
4	Capability to design new polymer materials through AI-driven insights	U, A	
5	Proficiency in using AI for advanced characterization of polymers	E, C, S	
6	Implementing AI techniques for quality control in polymer manufacturing	An, E, C, S	

*(Learning Domains: Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)

COURSE CONTENT

Module 1	**Hours**	**CO No**
Introduction to Polymers and AI: Fundamentals of polymer chemistry and polymer manufacturing processes, Basics of artificial intelligence and machine learning.	**10**	**1,2,3**
Module 2	**Hours**	
AI Techniques in Polymer Manufacturing: Data collection and preprocessing for polymer manufacturing,	**15**	**3,4**

Machine learning algorithms for process optimization, Predictive modelling of polymer properties, Case studies on AI applications in polymer production		
Module 3	**Hours**	
AI in Polymer Characterization: Techniques for polymer characterization, AI-based methods for analysing polymer structures, Image analysis, and pattern recognition in polymer characterization, Practical applications and software tools for AI in characterization	**15**	**4,5**

Mode of Transaction	**Classroom activities:** • Interactive lectures • Group discussions and problem-solving exercises • Quizzes and Assignments **Lab based activities:**
Mode of Assessment	• Assignments • Internal examination • End-semester examination

Learning Resources

- Artificial Intelligence in Polymer Science and Technology" by Satya N. Sahoo, Swadhin K. Behera
- Machine Learning for Materials Science" by Rajiv S. Nair, Surya R. Choudhury, and Nikhil R. Choudhury

Relevance of Learning the Course/ Employability of the Course
This course provides students with a highly relevant skill set that is in demand across various high-tech industries. The application of AI in optimizing manufacturing processes, improving material properties, and innovating new polymer materials positions graduates well for careers in diverse sectors, ensuring strong employability and growth in their professional journey.

	MAHATMA GANDHI UNIVERSITY **Graduate School**
	4 + 1 Integrated UG and PG Programme

School	International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	Nanostructures from Natural Origin		
Course Type	Skill Enhancement Course		
Course Level	200-299		
Course Code	MG4SECUCN203		
Course Overview	This syllabus is designed to introduce students to nanostructures derived from natural sources, focusing on their synthesis, properties, applications, and potential future developments. The course is divided into three modules, each covering essential aspects of natural nanomaterials.		
Semester	4	**Credit**	3

Total Student Learning Time	Instructional hours for theory	Instructional hours for practical/lab work/field work
	45	NA
Pre-requisite	All discipline	

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Acquire fundamental knowledge of natural nanostructures and their synthesis mechanisms.	U	
2	Identify and describe the types and properties of nanostructures found in nature.	E	
3	Analyse and explain the functional properties of natural nanostructures.	An	
4	Develop an understanding of the applications of these nanomaterials in various industries.	A	
5	Develop a comprehensive understanding of the environmental, ethical, and regulatory aspects of natural nanomaterials.	U	
6	Critically assess the future potential and challenges of nanomaterials sourced from nature.	E	

*(Learning Domains: Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)

COURSE CONTENT

Module 1	**Hours**	**CO No**
Introduction to Nanostructures from Natural Sources: Introduction to Nanotechnology, Natural Nanostructures, Synthesis Mechanisms of Natural Nanostructures, Characterization Techniques	15	1, 2
Module 2	**Hours**	
Properties and Functionalities of Natural Nanostructures: Physical and Chemical Properties of Natural Nanostructures, Biological Properties and Biocompatibility, Functional Applications	15	3, 4
Module 3	**Hours**	
Environmental and Ethical Considerations of Nanostructures from Natural Origin: Environmental Impact of Natural Nanostructures, Regulation and Safety Concerns, Challenges and Future Directions, Real-world examples of natural nanostructures used in industry and research	15	5, 6

Mode of Transaction	**Classroom activities:** • Interactive lectures • Group discussions and problem-solving exercises • Quizzes and Assignments **Lab based activities:**
Mode of Assessment	• Assignments • Internal examination • End-semester examination

Learning Resources

- "Nanostructures & Nanomaterials: Synthesis, Properties & Applications" by Guangwen Zhou and Wenxing Li

- "Nanobiotechnology: Concepts, Applications, and Perspectives" edited by Christof M. Niemeyer and C. A. Mirkin

- "Biomaterials Science: An Introduction to Materials in Medicine" by Buddy D. Ratner, Allan S. Hoffman, and Frederick J. Schoen

- "Natural Nanostructures in Biochemistry" by L. J. Safran

Relevance of Learning the Course/ Employability of the Course
This course is highly relevant as it provides interdisciplinary knowledge that bridges nanotechnology, biology, chemistry, and environmental science, preparing students to address global challenges related to sustainability, health, and technology.

	MAHATMA GANDHI UNIVERSITY **Graduate School**
	4 + 1 Integrated UG and PG Programme

School	International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	**Fundamentals of Nanostructured Polymer Foams**		
Course Type	VAC		
Course Level	200-299		
Course Code	MG4SECUCN204		
Course Overview	This course offers a comprehensive overview of polymer foams, exploring their fundamental properties, production technologies, and wide-ranging applications. It delves into the science behind foam structures, key manufacturing processes, and their use in industries such as packaging, construction, automotive, and healthcare.		
Semester	4	**Credit**	3
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	45 (L) + 15(T)	NA	
Pre-requisite	Understanding of Basic Chemistry		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Understanding the properties of polymer foams, how they are processed, and the predominant materials involved in their manufacturing.	R, U, A	
2	The main concepts regarding foaming processes and formulations to tailor their properties.	U, A, An	
3	The main types of polymeric foams along with some of the chemistry involved in their manufacturing and their general properties.	U, A, E	
4	The fabrication methods of polymeric foams along with the main materials employed for each method and their respective advantages and disadvantages.	U, A, C	
5	The main applications of polymeric foams.	U, A, S	

*(Learning Domains: Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S)

COURSE CONTENT

Module 1: Introduction to Polymeric Foams	**Hours**	**CO No**
Polymeric foams and their influence in the global market. Foaming processes and formulations to tailor their properties. The main types of polymeric foams along with some of the chemistry involved in their manufacturing and their general properties. The fabrication methods of polymeric foams along with the main materials employed for each method and their respective advantages and disadvantages.	**14**	**1,2,3**
Module 2: Foaming Technology	**Hours**	

Extrusion foaming, batch foaming, thermoset reactive foaming, compression foaming, rotational foam molding, injection foam molding, film foaming, bead foaming, and so forth—all of which are some of the well-established polymer foam production techniques—are key features that are discussed in this chapter.	**14**	**2,3**
Module 3: Micro, Macro and Nano Polymer foams- Materials, Synthesis, Technology, and Applications	**Hours**	
Thermoplastic Elastomeric Foams, Polystyrene Foams, Polyurethane Foams, Epoxy Foams, Phenolic foams, Polyethylene Foam, Ethylene-Vinyl Acetate Foam, Silicone Foams, Polyvinyl Chloride Foam, Polyimide Foam	**15**	**4,5**

Mode of Transaction	**Classroom activities:** • Interactive lectures • Group discussions and problem-solving exercises • Quizzes and Assignments **Lab based activities:**
Mode of Assessment	• Assignments • Internal examination • End-semester examination

Learning Resources

1. Polymeric Foams: Fundamentals and Types of Foams (Volume 1) eISBN: 9780841297173
2. Handbook of Manufacturing Engineering and Technology https://doi.org/10.1007/978-1-4471-4670-4
3. Complex Macromolecular Systems I https://doi.org/10.1007/978-3-642-12876-9
4. Handbook of Thermosetting Foams, Aerogels, and Hydrogels, From Fundamentals to Advanced Applications

Relevance of Learning the Course/ Employability of the Course
Learning this course equips students with specialized knowledge in polymer foams, a critical material in various industries such as automotive, construction, aerospace, packaging, and healthcare.