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
School of Nanoscience and Nanotechnology

Course Code	Title	Credits	Hours per Week		Level	Type
			Theory	Practical		
SEMESTER I						
MG1DSCUNN121	Art of Nanomaterial Synthesis	4	4	-	Foundation (100-199)	Minor A
MG1MDCUNN101	Nano world: History and Evolution	3	3	-	"	MDC
SEMESTER II						
MG2DSCUNN121	Basics of Nanoscience	4	4	-	Foundation (100-199)	Minor A
MG2MDCUNN101	Nanomaterials in Practice: Real-world Applications	3	3	-	"	MDC
SEMESTER III						
MG3DSCUNN221	Nanoscience in Biology	4	4	-	Intermediate (200-299)	Minor A
MG3MDCUNN201	Introduction to Functional Nanomaterials	3	3	-	"	MDC
MG3MDCUNN202	Nanomaterials Properties and Characterization	3	3	-	"	MDC
MG3MDCUNN203	Fundamentals of Computational Material Science and Engineering	3	3	-	"	MDC
MG3MDCUNN204	Modeling and Simulation of Functional Materials	3	3	-	"	MDC
MG3VACUNN201	Environmental Remediation through Nanotechnology	3	3	-	"	VAC

MG3VACUNN202	Green Nanotechnology	3	3	-	"	VAC
SEMESTER IV						
MG4DSCUNN241	Artificial Intelligence and Nanoinformatics	4	4	-	Intermediate (200-299)	Minor B
MG4VACUNN201	Nanotechnology for Agriculture	3	3	-	"	VAC
MG4VACUNN202	Nanotechnology in Food and Health	3	3	-	"	VAC
SEMESTER V						
MG5VACUNN301	Nanotoxicology and Ethics	3	3	-	Higher (300-399)	VAC
MG5VACUNN302	Nanotechnology for Sustainable Energy	3	3	-	"	VAC
MG5SECUNN301	Nanodevice Design and Fabrication Techniques	3	3	-	"	SEC
SEMESTER VI						
MG6SECUNN302	Advanced Electron Microscopic Techniques for Nanomaterial Characterization	3	2	2	Higher (300-399)	SEC
MG6SECUNN303	Scanning Probe Techniques for Nanoscale Characterization	3	2	2	"	SEC
MG6SECUNN304	X-Ray Crystallography for Nanomaterial Structural Analysis	3	2	2	"	SEC
Total Credits						

SEMESTER VII

MG7DSCUNN421	Advanced Computational Material Science and Engineering	4	2	4	Advanced (400-499)	Minor B
SEMESTER VIII						
Total Credits						
SEMESTER IX						
SEMESTER X						
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 (100-199	Intermediate (200-299)	Higher (300-399)	Advanced (400-499)	PG Level (500-599)

Type	Major	Minor	MDC	SEC	VAC	AEC

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

School	School of Nanoscience and Nanotechnology		
Programme			
Course Title	Nano world: History and Evolution		
Course Type	MDC		
Course Level	100-199		
Course Code	MG1MDCUNN101		
Course Overview	This course offers an introductory course to explore the fascinating world of nanoscience and nanotechnology, tracing its historical development and examining its profound impact on modern science and society. Through a blend of theoretical insights and practical case studies, students will gain a comprehensive understanding of the fundamental concepts of nanostructures - classifications, current opportunities, challenges, ethical considerations, and emerging trends in the field of nanoscience and nanotechnology.		
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 disciplines		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	Upon completion of this course, students will be able to;		
1	Provide a foundation in Nanoscience and Nanotechnology that emphasizes historical milestones, basic understanding and conceptualisation.	U	
2	Expose the students to various nanomaterials, classifications and how these nanomaterials differ from their bulk	A	
3	Promote research interest in students and enable them towards planning and execution of research in frontier areas of nanoscience and nanotechnology.	C	
4	Provide a discussion and critical thinking on ethical, environmental and societal implications of nanotechnology and its interdisciplinary nature.	E	
5	Exposure to various applications and case studies enables students to clearly understand their responsibilities towards societal needs and sustainable development.	An	
6	Investigate future trends and emerging opportunities in nanoscience and nanotechnology, preparing to contribute to ongoing advancements and interdisciplinary applications in the field.	An	

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

COURSE CONTENT

Module 1	Hours	CO No
Definition and scope of nanoscience and nanotechnology, Historical milestones from ancient uses to modern developments, Nano vision - Richard Feynman's lecture "There is plenty of room at the bottom", importance and	15	1, 4

impact of nanotechnology, the evolution of nanotechnology- breakthroughs in microscopy, overview of nanomaterials, fundamental concept of nanoscience-nanoscale and its significance.		
Module 2	**Hours**	
Fundamental properties of nanomaterials- large surface to volume ratio, quantum effect. Classification of nanostructures: one dimensional (ID), two dimensional (2D), three dimensional (3D). Types of nanostructured materials - quantum dots, quantum wire, quantum sheet structures. Carbon nanotubes (CNT), Metals (Au, Ag), Metal oxides (TiO2, Zno), semiconductors (Si, Ge, CdS, ZnSe), Ceramics and composites.	15	1, 2
Module 3	**Hours**	
Recent advancement - cutting-edge research. Case studies on nanotechnology applications – Biomedical, agriculture, energy storage and conversion, nanoelectronics and engineering applications. Challenges-Ethical, environmental and societal implications. Future trends and opportunities.	15	3, 5, 6

Mode of Transaction	**Classroom activities:** Interactive lectures, discussions, and presentations. **Field activities:** NA **Lab based activities:** NA
Mode of Assessment	Attendance: 10% Assignment: 10% Internal Exam: 20% Final Exam: 60%

Learning Resources

1. Charles P. Poole Jr., Frank J. Owens, "Introduction to Nanotechnology", Wiley-Interscience, ISBN-13: 978-0471079354.
2. T. Pradeep, "A Textbook of Nano Science and Technology", Tata McGraw-Hill Education, 2012.
3. Dale A. Stirling, "The Nanotechnology Revolution: A Global Bibliographic Perspective", Jenny Stanford Publishing, ISBN: 9789814774192.

4. Fritz Allhoff, Patrick Lin, James H. Moor, John Weckert, Mihail C. Roco, "Nanoethics: The Ethical and Social Implications of Nanotechnology", Wiley, 1st edition, August 31, 2007.
5. "Nanotechnology: Recent Trends, Emerging Issues and Future Directions", Nova Science Publishers, ISBN: 978-1-63117-561-9.
6. Michael F. Ashby, Paulo J. Ferreira, Daniel L. Schodek, "Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers and Architects", Elsevier, 2009.
7. Stuart Lindsay, "Introduction to Nanoscience", OUP Oxford, ISBN-13: 978-0199544219.
8. Jeremy Ramsden, "Nanotechnology: An Introduction", ISBN: 9780323393119 (eBook ISBN: 9780323393140).

Relevance of Learning the Course/ Employability of the Course
Graduates of this course possess a deep understanding of nanotechnology's foundational concepts, ethical considerations, and practical applications, making them valuable assets in roles related to research and development. Additionally, the interdisciplinary nature of nanotechnology empowers graduates to adapt to diverse environments and collaborate across various fields, further enhancing their competitiveness in the job market.

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

School	School of Nanoscience and Nanotechnology		
Programme			
Course Title	Nanomaterials in Practice: Real-world Applications		
Course Type	MDC		
Course Level	100-199		
Course Code	MG2MDCUNN101		
Course Overview	This course explores the vast and transformative applications of nanomaterials in biomedical, agricultural, food, defense, and aerospace industries. Students will gain basic understanding of medical diagnostics, drug delivery, and therapeutic treatments. The course will also cover the agricultural practices and food safety through nanotechnology. In addition, students will learn about the critical role of nanotechnology in defense and aerospace applications, including detection and diagnostics of chemical and biological threats, satellite communications, and spacecraft thermal control.		
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 disciplines		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	Upon completion of this course, students will be able to;		
1	Understand the role of nanomaterials in real world applications.	U	
2	Explore the application of nanomaterials in biomedical field and their significance for human kind.	An	
3	Apply nanotechnology principles to enhance agricultural practices and food industry.	A	
4	Provide a discussion and critical thinking on interdisciplinary nature of nanoscience and nanotechnology.	E	
5	Exposure to various applications and case studies enables students to evaluate and analyse the role of nanotechnology in defence, satellite communication and aerospace applications.	An	
6	Promote research interest in students in the frontier areas of biomedical, agriculture, food packaging, defence and aerospace applications.	C	

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

COURSE CONTENT

Module 1	**Hours**	**CO No**
Biosensors- Biological imaging using nanomaterials – Biomarker Imaging – Nanomaterials in bone substitutes and dentistry – Implants and Prosthesis – Tissue Engineering – Skin Tissue repairs, Vascular grafts – Nanosensors in Diagnosis – Drug delivery – Cancer therapy and other therapeutic applications.	15	1, 2, 4, 6
Module 2	**Hours**	
Nanotechnology in Agriculture -Precision farming, Smart	15	1, 3, 4,

delivery systems – Insecticides using nanotechnology – Potential of nano-fertilizers – Potential benefits in Nanotechnology in Food industry – Food processing - Packaging- Packing materials; physical properties. Sensors- RF identification- Food safety- Nanomaterial based Food diagnostics – Contaminant detection – Intelligent packaging.		6
Module 3	**Hours**	
Pathways to Physical protection- Detection and diagnostics of chemical and biological agents, Nanotechnology enabled biochemical weapons. Nanotechnology based satellite communication system- Guidance, Navigation and control. Spacecraft thermal control- mini, micro, nanosatellite concepts- Fiber optic and Chemical microsensors for space craft and launch support- Micro/Nano pressure and temperature sensors for space missions.	15	1, 4, 5, 6

Mode of Transaction	**Classroom activities:** Interactive lectures, discussions, and presentations. **Field activities:** NA **Lab based activities:** NA
Mode of Assessment	Attendance: 10% Assignment: 10% Internal Exam: 20% Final Exam: 60%

Learning Resources

1. Mark A. Ratner and Daniel Ratner, "Nanotechnology: A Gentle Introduction to the Next Big Idea", Pearson, 2003.
2. Bharat Bhushan, "Springer Handbook of Nanotechnology", Springer, 2004.
3. Neelina H. Malsch (Ed.), "Biomedical Nanotechnology", CRC Press, 2005.
4. Udo H. Brinker, Jean-Luc Mieusset (Eds.), "Molecular Encapsulation: Organic Reactions in Constrained Systems", Wiley Publishers, 2010.
5. Jennifer Kuzma and Peter Ver Hage, "Nanotechnology in Agriculture and Food Production", Woodrow Wilson International Center, 2006.

6. Lynn J. Frewer, Willem Norde, R. H. Fischer, and W. H. Kampers, "Nanotechnology in the Agri-Food Sector", Wiley-VCH Verlag, 2011.
7. P. J. Brown and K. Stevens, "Nanofibers and Nanotechnology in Textiles", Woodhead Publishing Limited, Cambridge, 2007.
8. Y.-W. Mai, "Polymer Nanocomposites", Woodhead Publishing, 2006.
9. W. N. Chang, "Nanofibers Fabrication, Performance and Applications", Nova Science Publishers Inc, 2009.
10. H. Helvajian and E. Y. Robinson, "Micro and Nanotechnology for Space Systems", The Aerospace Corporation, Micrograph, 1997.
11. Margaret E. Kosal, "Nanotechnology for Chemical and Biological Defense", Springer, 2009.
12. A. K. Alves (Ed.), "Technological Applications of Nanomaterials", Springer Cham, 2022.

Relevance of Learning the Course/ Employability of the Course
Understanding the applications of nanomaterials across diverse industries is crucial for today's professionals seeking to stay competitive in rapidly advancing fields. Proficiency in nanotechnology is essential for career opportunities in biomedical research and development, transforming diagnostics, drug delivery, and tissue engineering. Understanding nanotechnology in agriculture and food sectors fosters sustainable farming practices, ensures food safety, and drives product innovation on a global scale. In defense and aerospace, nanotechnology expertise supports the development of cutting-edge sensors, communication systems, and spacecraft technologies crucial for national security and exploration efforts. Mastering these applications enhances employability across research institutes, pharmaceutical companies, agricultural firms, and aerospace agencies, empowering individuals to lead innovation in a globally interconnected economy propelled by technological progress.

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

School	School of Nanoscience and Nanotechnology		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	Nanoscience in Biology		
Course Type	Minor A		
Course Level	200-299		
Course Code	MG3DSCUNN221		
Course Overview	This course introduces the principles, techniques, and applications of nanotechnology in biology. It covers the fundamental aspects of nanomaterials, their interaction with biological systems, and their role in advancing biomedical research, diagnostics, and therapeutics. Students will explore the integration of nanotechnology in biology and its potential for revolutionizing medicine and health sciences.		
Semester	3	**Credit**	4
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	60	NA	
Pre-requisite	• All disciplines		

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 fundamental concepts of nanotechnology.	U	
2	Understand the basic principles of biology.	U	
3	Describe the interaction of nanoparticles with biological systems	An	
4	Apply the principles of nanotechnology in theranostics.	A	
5	Explore the ethical concerns surrounding the use of nanotechnology in biology.	E	
6	Learn the regulatory frameworks governing nanotechnology research and applications.	An	

*(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 in biology: Definition and history of nanotechnology, Overview of nanoscience and nanotechnology in biological contexts. Basic principles of cell biology: cell theory, gene theory, evolution, homeostasis, and laws of thermodynamics.	15	1,2
Module 2	**Hours**	
Nanotechnology in cellular and molecular biology: Nanoparticle-cell interactions, mechanisms of nanomaterial penetration into cells, biological barriers and challenges in nanomedicine.	15	1, 2, 3
Module 3	**Hours**	

Nanotechnology in theranostics: Overview of nanomaterials for diagnosis, drug delivery, tissue regeneration, wound healing and cancer therapy.	15	3, 4
Module 4	**Hours**	
Ethical, safety, and regulatory aspects of nanotechnology in biology: Ethical considerations in nanotechnology applications in biology, future trends in nanotechnology regulation and ethical guidelines.	15	5,6

Mode of Transaction	**Classroom activities:** Interactive lectures, discussions, and presentations. **Field activities:** NA **Lab based activities:** NA
Mode of Assessment	Attendance: 10% Assignment: 10% Internal Exam: 20% Final Exam: 60%

Learning Resources

1. "Introduction to Nanotechnology" by Charles P. Poole Jr. and Frank J. Owens.
2. "Nanotechnology: Principles and Practices" by Sulabha K. Kulkarni.
3. "Nanobiotechnology: Concepts, Applications, and Perspectives" by Christof M. Niemeyer and Chad A. Mirkin.
4. "Nanotechnology in Medicine and Biology: From Nano-Bio-Device to Nano-Bio-Applications" by Shyong H. Kuo.
5. "Nanomedicine: Nanotechnology, Biology, and Medicine" by Robert A. Freitas.
6. "Nanotechnology in Drug Delivery" edited by Raj Bawa.
7. "Nanotechnology: Health and Environmental Risks" by Michael R. A. B.
8. "Nanotoxicology: Characterization, Dosing and Health Effects" edited by Qing-Yu Wu and Sunil K. Khuller.

Relevance of Learning the Course/ Employability of the Course
The study of Nanotechnology in Biology is extremely relevant as it equips students with the tools and knowledge to tackle modern challenges in the fields of medicine,

healthcare, environmental sustainability, and biotechnology. By understanding the principles of nanotechnology, its applications in biology, and the ethical and safety considerations, students are well-positioned to lead and innovate in this exciting, rapidly-evolving field.

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

School	School of Nanoscience and Nanotechnology		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	Nanomaterials Properties and Characterization		
Course Type	MDC		
Course Level	200-299		
Course Code	MG3MDCUNN202		
Course Overview	This course provides an in-depth exploration of nanomaterials, focusing on their unique properties, and advanced characterization methods. It bridges fundamental concepts from physics, chemistry, and materials science to explain the size-dependent behaviors of nanostructures and their relevance to real-world applications. Students will gain experience with state-of-the-art tools used to characterize nanomaterials, such as microscopy, spectroscopy, and thermal analysis techniques.		
Semester	3	**Credit**	3
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	40	5	
Pre-requisite	• All disciplines		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	Upon completion of this course, students will be able to;		
1	Demonstrate knowledge of the classification of nanomaterials, and explain their unique size-dependent properties.	U	
2	Apply principles of physics, chemistry, and materials science to analyze the optical, electronic, magnetic, and mechanical properties of nanomaterials.	A	
3	Analyze and interpret data obtained from characterization tools to deduce the structural, chemical, and physical attributes of nanomaterials.	An	
4	Select and utilize appropriate characterization techniques such as SEM, TEM and XRD to investigate the properties of nanomaterials.	E	
5	Develop analytical skills in nanotechnology to devise solutions for real-world problems.	A	
6	Demonstrate proficiency in using advanced tools and techniques for nanomaterial characterization, while adhering to laboratory safety protocols and ethical practices.	S	

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

COURSE CONTENT

Module 1:	Hours	CO No

Overview of nanostructures, its properties: Nanostructures: Understanding the nanoscale (1-100 nm), comparison between nanoscale, atomic scale, and bulk materials. 0D, 1D, 2D and 3D materials. Emergence of Size-dependent Properties: Surface area to volume ratio, Role of surface atoms and surface energy. Properties of Nanostructures: Electronic, optical, mechanical, magnetic and thermal properties. Challenges with nanoscale properties, Recent development in nanoscale characterization.	12	1, 2
Module 2:	**Hours**	
Advanced tools for analysis of nanoscale properties: Resolution Vs wavelength, X-ray techniques for structural analysis, Need of electrons for microscopy: SEM and TEM. Probing the atomic scale properties: Scanning Tunneling microscopy (STM), Atomic Force Microscopy (AFM). Special techniques for analysis of mechanical, magnetic and thermal properties.	13	3, 4
Module 3:	**Hours**	
Spectroscopy as a tool to analyze nanoscale properties Overview of Spectroscopy: Principles of light-matter interaction (absorption, emission, scattering), Importance of spectroscopy in analyzing nanoscale properties. Key Spectroscopy Techniques for Nanomaterial Characterization: absorption, emission, DLS spectroscopy and Raman spectroscopy. Comparison and Integration of analysis Techniques: Case study. *Lab visit for familiarization of sophisticated instruments.*	20	3, 5, 6

Mode of Transaction	**Classroom activities:** Interactive lectures, discussions, and presentations. **Field activities:** Visit to instrumentation facility for familiarization of common analytical instruments. **Lab based activities:** Submit a short case study report focusing characterization of nano materials.
Mode of Assessment	Attendance: 10% Assignment: 10% Internal Exam: 20% Final Exam: 60%

Learning Resources

1. Charles P. Poole Jr., Frank J. Owens, "Introduction to Nanotechnology", Wiley-Interscience, ISBN-13: 978-0471079354.
2. T. Pradeep, "A Textbook of Nano Science and Technology", Tata McGraw-Hill Education, 2012.
3. Guozhong Cao and Ying Wang, "Nanostructures and Nanomaterials", 2nd edition published by Imperial College Press in 2004.
4. Douglas A. Skoog , F. James Holler, and Crouch, Instrumental analysis, 7th edition , Cengage, 2009.
5. B.S.Murthy, P Shankar, Baldev Raj, B.B. Rath and James Murday, Text book of Nanoscience and Nanotechnology, Universeties press (India) ISBN: 978-3-642-28030-6, 2013.

Relevance of Learning the Course/ Employability of the Course
This course provides students with a comprehensive understanding of nanostructures, highlighting the relationship between their unique properties and the techniques used to measure them. It builds a strong foundation in nanoscience while equipping students with the knowledge and skills needed to tackle real-world challenges through nanotechnology. Through this course, students will develop a strong foundation in nanoscience, acquire industry-relevant skills, and enhance their employability in research, academia, and technology-driven industries.

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

School	School of Nanoscience and Nanotechnology		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	Modeling and Simulation of Functional Materials		
Course Type	MDC		
Course Level	200-299		
Course Code	MG3MDCUNN204		
Course Overview	Computational modelling approaches provide insights into materials aspects at atomic, micro, macro length scales and aid in better understanding of materials and processes. Course covers the fundamentals of computational science and its role in developing and optimising novel functional materials. This course combines theoretical and lab activities to explore the possibilities of computational tools in designing innovative materials. It also introduces students to various methods for material discovery and optimisation.		
Semester	3	**Credit**	3
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	35	10	
Pre-requisite	Basic knowledge of science		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	gain exposure to fundamental materials science and the materials classification.	U	
2	gain introductory and comprehensive knowledge about functional and energy materials.	A	
3	apply knowledge of mathematics, science, and engineering to problems in materials science and engineering	E	
4	acquire exposure to quantum mechanical computational techniques	E	
5	be familiar with and learn a variety materials modeling methods including electronic structure, molecular dynamics, Monte Carlo, finite differences, finite elements, and microstructure evolution methods	S	
6	use the techniques, skills, and computational and data analysis tools necessary for materials science engineering practice.	C	

*(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 functional materials, Structure of atoms and molecules. Atomic bonding in solids-binding energy, crystal lattices. Quantum effects, 1D, 2D and 3D nanoparticles and confinement. Optical, electronic, and magnetic properties of functional materials, include: Solar	15	1, 2

Cell, Battery Materials, Li-ion battery, Ferroelectric materials, piezoelectric generators etc.		
Module 2	**Hours**	
Modelling and applications of functional materials: Basic ideas of molecular modelling and electronic structure calculations, Coordinate systems and optimization methods. Molecular visualization and surfaces. Solution of ordinary differential equations, Initial value and boundary value problems, Solution of partial differential equations, vectors and tensors, Linear algebra. Computer architecture, basics of LINUX operating system.	15	3,4
Module 3	**Hours**	
Programming fundamentals Programming with MATLAB, Fortran, and Gaussian 09, Molecular dynamics: Interatomic potentials, Equation of motion, Neural networks and Genetic algorithms. Application of AI and ML for design of functional materials.	15	4,5,6

Mode of Transaction	**Classroom activities:** Interactive lectures, discussions, and presentations. **Field activities:** NA **Lab based activities:** NA
Mode of Assessment	Attendance: 10% Assignment: 10% Internal Exam: 20% Final Exam: 60%

Learning Resources

1. Schwartz M. (Ed.) Smart Materials, CRC Press, Taylor and Francis Group, 2009
2. Charles Kittel, Introduction to Solid State Physics, Wiley, 5th Edition, 1976
3. A. J. Dekker, Solid State Physics, Prentice Hall, 1957.
4. N. W. Ashcroft and N. D. Mermin, Solid State Physics, Saunders College Publishing,
1976
5. M. Boas, Mathematical Methods in Physical Sciences, 2nd Edition, Wiley International Edition, 1983

6. E. Kreyszig, Advanced Engineering Mathematics, Wiley Eastern, 5th Edition, 1991
7. Rappaz, M., Bellet, M., Deville, M., Numerical Modeling in Materials Science and Engineering, Springer Science & Business Media, 2010.
8. Frenkel, D., Smit, B., Understanding Molecular Simulation: From Algorithms to Applications, 2nd Edition, Elsevier 2001.
9. Lee, J. G., Computational Materials Science: An Introduction, 2nd edition, CRC Press, 2016.
10. Sholl, D. S., and Steckel, J. A., Density Functional Theory: A Practical Introduction, 1st Edition, Wiley, 2009.

Relevance of Learning the Course/ Employability of the Course
The primary goal of this course is to introduce students to materials simulation techniques and their use to characterize a wide range of phenomena from electronic and atomic structure to macroscopic behaviour of energy and functional materials. Graduates are able to manage projects and work in interdisciplinary teams using state-of-the-art materials simulation and analysis techniques to create novel materials solutions for innovative energy and electronic applications.

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

School	School of Nanoscience and Nanotechnology		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	Green Nanotechnology		
Course Type	VAC		
Course Level	200-299		
Course Code	MG3VACUNN202		
Course Overview	Green Nanotechnology is an interdisciplinary field that combines sustainability principles with nanoscience and nanotechnology. This course provides an in-depth exploration of green nanotechnology, emphasizing sustainable nanomaterial synthesis and their diverse applications in energy, healthcare, agriculture, and more. Students will develop an understanding of nanotechnology's environmental impact and discover innovative strategies to minimize its ecological footprint. Additionally, the course will investigate the properties and applications of plant-based, carbon-based, and other green nanomaterials while addressing real-world challenges and opportunities in the field. By the end of the course, students will acquire the knowledge and skills needed to apply green nanotechnology principles across various sectors, fostering sustainable solutions and innovation.		
Semester	3	**Credit**	3

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

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	Upon completion of this course, students will be able to;		
1	Explain the principles and scope of Green Nanotechnology.	U	
2	Analyze various green synthesis approaches for environmentally sustainable nanomaterials.	An	
3	Classify different types of green nanostructures and describe their synthesis from plant-derived and biopolymer-based sources.	An	
4	Evaluate the environmental, biomedical, agricultural, and industrial applications of green nanostructures.	E	
5	Identify emerging trends and challenges in Green Nanotechnology, assessing opportunities for sustainable development.	E	
6	Design and propose innovative green nanotechnology solutions to minimize the environmental footprint of industrial and consumer applications.	C	

*(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 Green Nanotechnology: Definition and Scope of Green Nanotechnology; Conventional versus Green Nanotechnology; Twelve Principles of Green Chemistry; Sustainable Synthesis Approaches- innovative approaches to minimize the environmental footprint of nanotechnology.	10	1,2

Module 2		
Green nanostructures and Synthesis: Types of green nanostructures - Plant derived nanostructures, nanostructures derived from polysaccharide, protein, lipid, carbon and silica. Green synthesis of nanostructures: Lignocellulosic Biomass-Derived Carbon Quantum Dots (CQDs); Chitin- and Chitosan-based nanomaterials; Solvent-free and biopolymer-assisted nanoparticle synthesis.	20	2,3
Module 3	**Hours**	
Applications of Green Nanotechnology: Applications of green nanostructures in energy and environment; agriculture and sustainable farming; biomedical and healthcare; sustainable packaging, textiles & cosmetics, electronic and smart devices. Emerging trends in green nanotechnology; Challenges and Opportunities**.**	15	4,5,6

Mode of Transaction	**Classroom activities:** Interactive lectures, discussions, and presentations. **Field activities:** Field visit and Case study **Lab based activities:**
Mode of Assessment	Attendance: 10% Assignment: 10% Internal Exam: 20% Final Exam: 60%

Learning Resources

1. An Introduction to Green Nanotechnology. Mahmoud Nasrollahzadeh, Mohammad S. Sajadi, Monireh Atarod, Mohaddeseh Sajjadi, Zahra Isaabadi.
2. Green Nanotechnology: Solutions for Sustainability and energy in the built environment-Geoffrey B. Smith, Claes-Goran S. Granqvist.
3. Green Chemistry and Engineering: A Practical Design Approach – Concepción Jiménez-González, David J. C. Constable.
4. Nanotechnology for Sustainable Development – Rajendra Kumar Goyal.
5. Green Nanomaterials: Advances and Applications – Kaushik Pal.

6. Green Nanotechnology: Fundamentals and Applications – Mamadou S. Diallo, Jeremiah Duncan, Nanthi S. Bolan.

Relevance of Learning the Course/ Employability of the Course
The course on Green Nanotechnology is highly relevant in today's world, as it aligns with the global push toward sustainability and eco-friendly technological advancements. By integrating the principles of green chemistry with nanotechnology, this course equips students with knowledge of environmentally responsible synthesis methods and sustainable applications of nanomaterials. The employability prospects for graduates are vast, spanning industries such as biomedical technology, sustainable packaging, renewable energy, agriculture, cosmetics, and electronic devices. With the increasing demand for green solutions, professionals trained in green nanotechnology will find opportunities in research institutions, environmental consulting, material science industries, and sustainable product development sectors.

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

School	School of Nanoscience and Nanotechnology		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	Artificial intelligence and Nanoinformatics		
Course Type	Minor B		
Course Level	200-299		
Course Code	MG4DSCUNN241		
Course Overview	This course aims to introduce the fundamental concepts of artificial intelligence (AI) and nanoinformatics to individuals from all academic backgrounds. Students will develop a broad understanding of AI technologies and their sub fields and their potential applications in various fields.		
Semester	4	**Credit**	4
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	50	10	
Pre-requisite	Basic science		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Define and explain the fundamental concepts of artificial intelligence (AI) and subfields, including machine learning and deep learning.	R	
2	Understanding the basic concepts of molecular modelling.	An	
3	Define the Fundamental concepts of deep learning and neural networks.	E	
4	Identify real-world applications of AI in nanoscience, chemistry, physics, biological science, and material science.	A	
5	Understand the recent advancement in artificial intelligence, nanoinformatics, and machine learning in different domains.	An	
6	Analyze the social, ethical, and economic implications of AI.	An	

*(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 artificial intelligence (AI) and nanoinformatics: Introduction to AI, history and evolution, inverse design problems using AI, language models (e.g., GPT, BERT), numerical optimization techniques, stochastic optimization, genetic algorithms.	15	1, 4
Module 2	**Hours**	
AI Subfields and Technologies: Human learning and it's types; machine learning and it's types; Supervised learning, unsupervised learning, reinforcement learning, and neural networks. Basics of statistical data analysis, fitting and regression.	15	1, 2
Module 3	**Hours**	

Applications of AI: AI in healthcare: Diagnosis and treatment. AI in nano energy storage and conversion applications. AI in Drug Design. AI in transportation: Autonomous vehicles and traffic optimization. AI in finance: Fraud detection.	15	3, 5
Module 4		
Ethical and Social Implications of AI: Ethical guidelines and responsible AI practices. Challenges, environmental, and societal implications. Future trends and opportunities.	15	6

Mode of Transaction	**Classroom activities:** Interactive lectures, discussions, and presentations. **Field activities:** NA **Lab based activities:** NA
Mode of Assessment	Attendance: 10% Assignment: 10% Internal Exam: 20% Final Exam: 60%

Learning Resources

1. S. Russel and P. Norvig, "Artificial Intelligence - A Modern Approach", SecondEdition, Pearson Education.
2. B.Yegnanarayana, Artificial Neural Networks, Prentice Hall of India.
3. Satish Kumar, Neural Networks – A Classroom Approach, Tata McGraw-Hill.
4. David Poole, Alan Mackworth, Randy Goebel, "Computational Intelligence : a logical approach", Oxford University Press.
5. Introduction to Machine learning, Ethem Alpaydin, Third Edition, MIT Press,2009.
6. J. Nilsson, "Artificial Intelligence: A new Synthesis", Elsevier Publishers.

Relevance of Learning the Course/ Employability of the Course
The Artificial intelligence and nanoinformatics course equip students with foundational knowledge of artificial intelligence and its subfields and explore real-world applications of AI across different domains, also gain insights into the ethical, social, and economic implications of AI.

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

School	School of Nanoscience and Nanotechnology		
Programme	4 + 1 Integrated UG and PG Programme		
Course Title	Nanotechnology in Food and Health		
Course Type	VAC		
Course Level	200-299		
Course Code	MG4VACUNN202		
Course Overview	This course focuses on the basic concepts, investigation tools and fundamental issues of nanotechnology with emphasis on the applications of nanotechnology in food systems, healthcare, food safety, and food packaging. The relevance of nanoscience and nanotechnology to improve food production, food nutritive value and shelf life of food is discussed in this paper. Finally, the concept of nanomedicine and use of nanoscience in diagnosis of diseases are also explored.		
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 disciplines		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Understand how to use of Nanotechnology in food production.	U	
2	Analyse how nanotechnology concepts to deliver different functional food components.	An	
3	Apply Nanotechnology in food packaging	A	
4	Evaluate the environmental risk of nanomaterials in food	E	
5	Applications of nanotechnology in health and medicine	An	
6	Applications of nanotechnology in diagnosis and imaging	An	

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

COURSE CONTENT

Module 1	Hours	CO No
Nanotechnology in food production: Food and new ways of food production, Efficient fractionation of crops, Efficient product structuring, Optimizing Nutritional Values. Applications of Nanotechnology in Foods: Sensing, Engineering Food Ingredients to Improve Bioavailability - Nanocrystalline Food Ingredients, Nanoemulsions, Nano-Engineered Protein Fibrils.	15	1, 2
Module 2	**Hours**	

Nanotechnology in food packaging: Reasons to Package Food Products. Physical Properties of Packaging Materials – Strength, Barrier Properties, Light Absorption. Structuring of Interior Surfaces, Antimicrobial Functionality - Visual Indicators, Quality Assessment, Food Safety Indication -Product Properties. Smart nanomaterials for packaging. Toxicity and environmental risks of nanomaterials in food.	15	3,4
Module 3	**Hours**	
Concept of nanomedicines: Classification of nanomedicines. Transport of nanoparticles across the biological barriers. Parameters affecting binding and uptake of nanoparticles-size, shape, surface charge, protein corona, surface modification. Different mechanisms of receptor-mediated endocytosis. Different nanomaterials for imaging and diagnosis.	15	5, 6

Mode of Transaction	**Classroom activities:** Interactive lectures, discussions, and presentations. **Field activities:** NA **Lab based activities:** NA
Mode of Assessment	Attendance: 10% Assignment: 10% Internal Exam: 20% Final Exam: 60%

Learning Resources

1. Buddy D. Ratner , Allan S. Hoffman , Frederick J. Schoen, Jack E. Lemons, " Biomaterials Science: An Introduction to Materials in Medicine", Academic Press, 2012
2. Debasis Bagchi, Manashi Bagchi, Hiroyoshi Moriyama, Fereidoon Shahidi, "Bio-Nanotechnology: A Revolution in Food, Biomedical and Health Sciences" Wiley-Blackwell, 2013
3. Nanotechnology in agriculture and food production by Jennifer Kuzma and Peter VerHage, Woodrow Wilson International Center, (2006).
4. Nanotechnology in Modern Medical Imaging and Interventions. Xiaoming Yang. Nova Science Publisher.
5. The Clinical Nanomedicine Handbook. By Sara Brenner. CRC Press

6. Nanomedicines and Nanoproducts: Applications, Disposition, and Toxicology in the Human Body. Eiki Igarashi.
7. Novel Drug Delivery Systems. by Yie W. Chien 5. Introduction to Novel Drug Delivery Systems By N.K. Jain

Relevance of Learning the Course/ Employability of the Course
Graduates of this course possess a deep understanding of nanotechnology's application in food and healthcare. Additionally, the interdisciplinary nature of nanotechnology empowers graduates to adapt to diverse environments and collaborate across various fields, further enhancing their competitiveness in the job market.