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

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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

Course Code	Title	Credits	Hours per Week		Level	Type
			Theory	Practical's		
SEMESTER I						
	Major	4			Foundation (100-199)	
MG1DSCUEM121	**Fundamentals of Material Science**	4	2	2	"	Minor
MG1DSCUEM141	**Basics of Energy Science**	4	2	2	"	Minor
MG1MDCUEM101	**Energy crisis and Sustainable solutions**	3	3	-	"	MDC
	AEC (Eng)	3			"	
	AEC (Mal)	3			"	
SEMESTER II						
	Major	4			"	
MG2DSCUEM121	**Physics of Materials**	4	2	2	"	Minor
MG2DSCUEM141	**Materials Chemistry**	4	2	2	"	Minor
MG2MDCUEM101	**Fundamentals of Electrochemical Devices**	3	3	-	"	MDC
MG2MDCUEM102	**Bio Energy**	3	3	-		
	AEC (Eng)	3			"	
	AEC (Mal)	3			"	
SEMESTER III						
	Major	4			Intermediate (200-299)	
	Major	4			"	
	Major	4			"	
MG3DSCUEM221	**Energy Conversion, Storage and Transportation**	4	2	2	"	Minor
MG3DSCUEM222	**Introduction to Numerical Methods**	4	2	2		
MG3MDCUEM201	**Energy Management, Economics and Policies**	3	3	-	"	MDC
MG3MDCUEM202	**Solar Photovoltaics**	3	3	-		
MG3VACUEM201	**Renewable Energy Systems**	3	3	-	"	VAC
MG3VACUEM202	**Quantitative Aptitude and Reasoning**	3	3	-		
SEMESTER IV						
	Major	4			"	
	Major	4			"	
	Major	4			"	
MG4DSCUEM241	**Hydrogen and Fuel cells**	4	2	2	"	Minor
MG4DSCUEM242	**Heat and Thermodynamics**	4	2	2		
MG4SECUEM201	**Software Tools for Energy Analysis**	3	3	-	"	SEC
MG4SECUEM202	**Innovative Techniques in Academic Writing**	3	3	-		

MG4VACUEM201	**Waste to Energy Conversion**	3	3	-	"	VAC
MG4VACUEM202	**Smart materials and structures**	3	3	-		
	Internship/Fieldwork	2				
SEMESTER V						
	Major	4			Higher (300-399)	
	Major	4			"	
	Major	4			"	
	Major	4			"	
MG5SECUEM301	**Design and Installation of Solar panels**	3	2	2	"	SEC
MG5SECUEM302	**Thin film Fabrication Techniques**	3	2	2		
MG5VACUEM301	**Batteries and Supercapacitors**	3	3	-	"	VAC
MG5VACUEM302	**Innovation and Entrepreneurship**	3	3	-		
SEMESTER VI						
	Major	4			"	
	Major	4			"	
	Major	4			"	
	Major (E)	4			"	
	Major (E)	4			"	
MG6SECUEM301	**Flexible Electronics**	3	2	2	"	SEC
MG6SECUEM302	**Advanced Electrochemical Devices**	3	2	2		
Total Credits		**133**				

SEMESTER VII						
	Major	4			Advanced (400-499)	
	Major (E)	4			"	
	Major (E)	4			"	
MG7DSCUEM421	**Electric Vehicle Design**	4	2	2	"	Minor
MG7DSCUEM422	**MEMS & Nanofabrication**	4	2	2		
MG7DSCUEM423	**Spectroscopic Techniques for Material Science**	4	2	2		
MG7DSEUEM424	**Nanomaterials for Energy Harvesting and Storage Applications**	4	2	2	"	Minor
MG7DSEUEM441	**Structural & Morphological Characterization Techniques**	4	2	2	"	Minor
SEMESTER VIII						
	Major	4			"	
	Major (E)	4			"	
	Research Project	12			"	
	Major*	4			"	
	Major*	4			"	

	Major*	4			“	
Total Credits		**44**				
SEMESTER IX						
	Major	4			PG Level (500-599)	
	Major	4			“	
	Major	4			“	
	Major	4			“	
	Major	4			“	
SEMESTER X						
	Research Project	20			“	
	Major**	4			“	
	Major**	4			“	
	Major**	4			“	
	Major**	4			“	
	Major**	4			“	
Total Credits		**40**				

*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

SEMESTER I

	MAHATMA GANDHI UNIVERSITY **Graduate School**		
	4 + 1 Integrated UG and PG Programme		
School Name	**School of Energy Materials**		
Programme	**4 + 1 Integrated UG and PG Programme**		
Course Title	**Fundamentals of Material Science**		
Course Type	**Minor**		
Course Level	**100-199**		
Course Code	**MG1DSCUEM121**		
Course Overview	This foundational course introduces students to the essential principles of materials science. Beginning with an examination of atomic structure and chemical bonding, including ionic, covalent, metallic, and intermolecular bonds, students gain a comprehensive understanding of the fundamental building blocks of matter. They then move to crystal structure and properties, learning about lattice points, unit cells, crystal systems, and advanced topics such as X-ray diffraction techniques. Students will explore imperfections in solids, including point defects, dislocations, and interfacial defects, and understand their impact on material properties. The course also covers diffusion mechanisms, emphasizing Fick's laws and factors influencing diffusion. Through classroom lectures, discussion and assignments, students will gain a solid foundation in materials science, preparing them for advanced studies and engineering applications.		
Semester	**1**	**Credit**	**4**
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	45 Hours Teaching Hour	**30 Hour Practicum**	
Pre-requisite	A solid understanding of calculus, physics, and chemistry is required.		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	To know the evolution of materials science and understanding materials around us.	U	
2	Explain and Analyse various atomic bonds (ionic, covalent, metallic, van der Waals, dipole) and their energies.	U, An	

3	Analyse atomic structure, Crystal structure, Crystal axes and planes, X-ray diffraction data.	U, A, An	
4	Identify and classify defects (point defects, impurities, dislocations, interfacial, bulk) and understand atomic vibrations' impact on materials.	U	
5	Explain diffusion mechanisms, apply Fick's laws of diffusion, and analyse factors influencing diffusion in materials.	U, A, An	

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Module 1	CO No.	Hours
Introduction to engineering materials, Description of materials science, Classification of Materials, Atomic structure, Bohr atom model, Quantum numbers, Basic ideas of bonding, bonding forces and energies, ionic bonding, covalent bonding (hybridization), metallic bonding, van der Waals bonding, dipole bonds	**1,2**	**13 Hours**
Module 2	**3**	**13 Hours**
Lattice points and space lattice, basis and crystal structure, unit cell and primitive cell, seven crystal systems and fourteen Bravais space lattice, coordination number, nearest neighbour distance, atomic radius, atomic packing factor in crystal structure, calculation of lattice constant, lattice planes and Miller indices, separation between lattice planes, single crystals and polycrystalline materials, amorphous materials, X-ray diffraction, Bragg's law of X-ray diffraction.		
Module 3	**4**	**9 Hours**
Imperfections in Solids: Point Defects, Vacancies and Self-Interstitials, Impurities in Solids, Dislocations-Linear Defects, Interfacial Defects, Bulk or Volume Defects, Atomic Vibrations		
Module 4	**5**	**10 Hours**
Diffusion phenomenon: Diffusion Mechanisms; Vacancy Diffusion and Interstitial Diffusion, Steady-State Diffusion; Fick's first law, Nonsteady-State Diffusion; Fick's second law, Factors that influence Diffusion		

Mode of Transaction	Classroom activities Authentic learning, case-based learning, collaborative learning, seminar, group activities.

Mode of Assessment	**1. Continuous Internal Assessment** **(CIA) Internal Test** **Assignment –** Every student needs to write an assignment on a given topic based on the available published literature 2. **Seminar Presentation –** A topic needs to be presented and discussed with the class **3. Semester End Examination**

Learning Resources

1. Callister, William D., and David G. Rethwisch. *Fundamentals of materials science and engineering*. Vol. 471660817. London: Wiley, 2000.
2. William F. Smith, and Javad Hashemi. *Foundations of materials science and engineering*. Mcgraw- Hill Publishing, 2006.
3. Wahab, Mohammad Abdul. *Solid state physics: structure and properties of materials*. Alpha Science Int'l Ltd., 2005.
4. C. Kittel, Introduction to solid state physics

Relevance of Learning the course/ Employability of the course
Understanding engineering materials is essential for a wide range of industries and fields, making this course highly relevant for students pursuing careers in materials science, and related disciplines. It covers the atomic and molecular principles that governs material properties, essential for selecting and developing materials with tailored characteristics for specific applications. By exploring crystal structures, imperfections and diffusion phenomena in solids, the course enables students to advance in fields such as structural engineering, and nanotechnology.

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

School Name	**School of Energy Materials**		
Programme	**4 + 1 Integrated UG and PG Programme**		
Course Title	**Basics of Energy Science**		
Course Type	**Minor**		
Course Level	**100-199**		
Course Code	**MG1DSCUEM141**		
Course Overview	The course provides a comprehensive introduction to the fundamental principles and contemporary issues in energy production, utilization, and sustainability. This course covers a wide range of topics, including current energy scenarios, renewable energy sources, environmental impacts, and advanced energy storage technologies. It aims to equip students with the foundational knowledge necessary to understand and engage with the evolving landscape of energy science.		
Semester	**1**	**Credit**	**4**
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	45 Hours Teaching Hours	**30 Hour Practicum**	
Pre-requisite	No prior knowledge of energy science is required. A basic understanding of high school-level physics and chemistry will be beneficial.		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To investigate the correlations between energy production/utilization and environmental impact, emphasizing global warming and environmental degradation.	U, An	
2	To Explain Various Non-Conventional Energy Resources and their Usage.	E	

3	To compare biological energy sources with fossil fuels, analysing their environmental impacts and sustainability.	E, A	

4	To study the principles of photovoltaic energy conversion and the functioning of various types of photovoltaic cells.	R, A, S	
5	To understand the nanostructured materials, primary and secondary batteries, lithium-ion batteries, and the principles and trends of capacitors and supercapacitors.	C, An	
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module 1	Hours	CO No.
Fundamentals of Energy: Current energy scenario; Outline of alternative energy schemes, clean low cost, sustainable energy production based on renewable energy sources, Energy and environment correlations, Environmental degradation due to energy production and utilization, global warming; Environmental impact assessment of materials used in energy and applications and their properties, Overview of biomass as energy source, Biofuels.	**10**	**1**
Module 2	**10**	**2,3**
Conventional & Non-Conventional Energy Source: Biological energy sources and fossil fuels, Fluid dynamics and power in the wind, available resources, fluids, viscosity, types of fluid flow, lift, Wind turbine dynamics and design, wind farms, Geothermal power and ocean thermal energy conversion, Tidal/wave/hydro power		
Module 3	**13**	**4**
Solar Energy: Fundamentals of solar radiation and its measurement aspects, Basic physics of semiconductors, Carrier transport, generation and recombination in semiconductors, Semiconductor junctions: metal-semiconductor junction & p-n junction, Solar thermal conversion, principles of photovoltaic energy conversion, Types of photovoltaic cells, first, second and third generation solar cells, PV system design and economics.		
Module 4	**12**	**5**

Materials & devices for energy storage: Issues and challenges of functional nanostructured materials for electrochemical energy storage systems, Primary and Secondary batteries, Lithium-ion batteries, Current status and future trends. Capacitor, Electrochemical supercapacitors, Current status and future trends.		

Mode of Transaction	**Classroom activities** Authentic learning, case-based learning, collaborative learning, seminar, group activities.

Mode of Assessment	**1. Continuous Internal Assessment** **(CIA) Internal Test** **Assignment –** Every student needs to write an assignment on a given topic based on the available published literature 2. **Seminar Presentation –** A topic needs to be presented and discussed with the class **3. Semester End Examination**

Learning Resources

1. Energy and the Challenge of Sustainability, World Energy Assessment, UNDP, New York, (2000).
2. Physics of Solar Cells: From Basic Principles to Advanced Concepts by Peter Wurfel, John Wiley & Sons, 2016
3. Advanced Nanomaterials and their applications in Renewable energy, Jingbio louise Liu, Sajid Bashir, Elsevier, 2015
4. Nanostructured Materials for Solar Energy Conversion, Tetsuo Soga, Elsevier, 2006
5. Lithium Batteries: Science and Technology, G.A. Nazri and G. Pistoia, Kluwer Academic Publishers, Dordrecht, Netherlands, 2004.

Relevance of Learning the course/ Employability of the course
As the world shifts towards sustainable and renewable energy sources, understanding the fundamental principles of energy science becomes crucial. This course equips students with essential knowledge about various energy forms, conversion processes, and storage technologies, making them well-prepared to tackle contemporary energy challenges. With a strong foundation in energy science, graduates are highly employable in diverse sectors such as renewable energy, energy management, environmental consultancy, and research and development. This expertise is invaluable for roles in government agencies, private industry, and non-profit organizations dedicated to advancing sustainable energy solutions and improving energy efficiency.

	MAHATMA GANDHI UNIVERSITY **Graduate School**		
	4 + 1 Integrated UG and PG Programme		
School Name	**School of Energy Materials**		
Programme	**4 + 1 Integrated UG and PG Programme**		
Course Title	**Energy Crisis and Sustainable solutions**		
Course Type	**Multi - Disciplinary Course (MDC)**		
Course Level	**100-199**		
Course Code	**MG1MDCUEM101**		
Course Overview	This course provides a comprehensive examination of the global energy crisis, exploring the causes, impacts, and potential solutions to the world's growing energy demands and challenges. The course covers a wide range of topics including fossil fuels, renewable energy sources, energy efficiency, and solutions to prevent energy crisis. This course will discuss the sources, generation, transportation/distribution, and use of energy as well as the efficiency, side-effects, and dangers that are involved. Students will gain an understanding of the technical, economic, environmental, and geopolitical dimensions of energy production and consumption. Modern sustainable technologies for transportation to lighting, from industry to individual homes, are covered in this course.		
Semester	**1**	**Credit**	**3**
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
Pre-requisite	This course has no prerequisites and can be taken by anyone.		

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 various forms of energy and its importance	U	
2	To get an insight of energy crisis and energy conservation practices. Critically analyze the factors contributing to the global energy crisis.	U, An	

3	Understand the key factors influencing energy demand and consumption.	U	
4	Identify and evaluate various solutions to prevent the energy crisis.	U, An, E	
5	Develop strategic plans for integrating multiple solutions to address the energy crisis.	U, A, E	
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module 1	**Hours**	**CO No.**
Energy Scenario: Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, Final Energy Consumption, Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms. Fossil fuels and Renewable sources including Bio-fuels in India - Their utilization pattern in the past, present and future.	**10**	**1**
Module 2	**9**	**2**
Energy crisis –History of Energy Crisis - Types of Energy Crisis - Major cause of energy crisis - Over consumption, over population - Impact of Energy Crisis - Energy Crisis in India-Unexplored Renewable Energy Options – Commissioning of Power Plants.		
Module 3	**13**	**3,4**
Energy Demand and Sustainable Solutions; Energy consumption – energy consumption (per capita) and economic growth - Global energy consumption – Energy demand – primary energy demand and cumulative energy demand. Solutions to Prevent Energy Crisis - Embracing Renewable Energy - Enhancing Energy Efficiency - Innovating Energy Storage and Transmission - Advancing Nuclear Energy- Implementing Sustainable Energy Policies.		
Module 4	**13**	**5**
Sustainable Technologies: Introduction of Energy storage systems- Mechanical energy storage technologies - Conventional thermal energy conversion - Solar energy technologies - Wind energy technology- Batteries -Supercapacitors - Fuel cells - Tidal Energy - Thermal and vibrational energy harvesting - Water treatment and remediation.		

Mode of Transaction	**Classroom** **activities Field** **activities** **Lab based activities**
Mode of Assessment	**1. Continuous Internal Assessment (CIA)** ***Internal Test*** ***Assignment*** – Every student needs to write an assignment on a given topic based on the available published literature 2. **Seminar Presentation** – A topic needs to be presented and discussed with the class **3. Semester End Examination**

Learning Resources

1. Albert Thumann, D. Paul Mehta, *Handbook of Energy Engineering* , The Fairmont Press Inc - 6th edition, 2008.
2. D. Yogi Goswami, Frank Kreith, *Energy Management and Conservation Handbook*, CRC Press, 2007
3. Thipse. S.S. *Non- Conventional and Renewable energy sources*, Narosa Publishing House, 2014.
4. Robert A. Huggins, *Energy storage*, Springer Science & Business Media, 2010
5. Jenny A. Nelson, *The Physics of Solar Cells*, World Scientific Publishing Company, 2003.
6. Robert Huggins, *Advanced Batteries: Materials Science Aspects*, Springer; 2009.

Relevance of Learning the course/ Employability of the course
This course will give an overview to prevent an energy crisis is learning how to conserve energy, improving, and modernizing energy infrastructure with the help of sustainable technologies. By the end of this course students will be able to appreciate the physics of metals, semiconductors and insulators. The implementation of this course will help the students to understand specific techniques to resolve the energy problem. After completing the course, you will attain the ability to evaluate, appraise and provide solutions to the current energy crisis in the world.

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SEMESTER II

	MAHATMA GANDHI UNIVERSITY **Graduate School**		
	4 + 1 Integrated UG and PG Programme		
School Name	**School of Energy Materials**		
Programme	**4 + 1 Integrated UG and PG Programme**		
Course Title	**Physics of Materials**		
Course Type	**Minor**		
Course Level	**100-199**		
Course Code	**MG2DSCUEM121**		
Course Overview	This course provides an in-depth understanding of the physics of materials, focusing on the fundamental properties of various materials. Students will explore semiconductor physics, dielectric properties such as polarization and dielectric constants, and light-matter interactions including reflection and refraction. The course also covers magnetic properties, the classification of magnetic materials, and the phenomenon of superconductivity. Through these topics, students will gain comprehensive knowledge of material behaviours and their applications in modern technology**.**		
Semester	**2**	**Credit**	**4**
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	45 Hours Teaching Hours	**30 Hours Practicum**	
Pre-requisite	A solid grounding in introductory physics and basic materials science principles are required		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Differentiate crystalline and amorphous solids, understand lattice structures, unit cells, and Bravais lattices in seven crystal systems	R, U	

2	Gain knowledge of intrinsic and extrinsic semiconductors, band gaps, carrier concentrations, and the influence of doping on Fermi level.	R, U, An	
3	Describe the dielectric properties of materials, including polarization, capacitance, and ferroelectricity, and relate them to the underlying molecular structure.	U, An	
4	Explain the interaction of light with matter, including reflection, refraction, absorption, and emission processes.	U, An	
5	Classify magnetic materials based on their atomic structure and magnetic properties, and explain phenomena like diamagnetism, superconductivity, and hysteresis.	U, A, An	
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module 1	**Hours**	**CO No.**
Crystallography: Crystalline and amorphous solids, Lattice and Unit cell, Seven crystal system and Bravais lattice, Symmetry operation, Miller Indices, Atomic Radius, Coordination number, Atomic packing fraction.	7	1
Module 2	10	2
Semiconductor Physics: Introduction, Intrinsic and extrinsic semiconductors, Direct and Indirect band gap semiconductors, compound semiconductors. Carrier concentration in intrinsic semiconductor, carrier concentration in n-type and p-type semiconductor, Fermi level, Law of Mass action, Charge neutrality, Hall effect.		
Module 3	14	3,4
Dielectric properties: Polar and non-polar molecules, polarization, capacitance and dielectric constant, displacement vector, local electric field, Clausius– Mossotti relation, dielectric materials and ferroelectricity. Optical properties: Electromagnetic radiation, light-matter interaction: reflection, refraction, absorption and transmission, photoluminescence and photoconductivity.		

Module 4		
Magnetic properties: Atomic structure and quantum numbers, orbital and spin angular momentum, magnetic moment in uniform and non-uniform magnetic fields: energy, force and torque, Larmor precession, Classification of magnetic material; diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic and ferrimagnetic materials, magnetic domains and hysteresis Superconductors: Definition, Meissner effect, Type I & II superconductors, London equations, Cooper pair.	**14**	**5**

Mode of Transaction	**Classroom activities** Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Mode of Assessment	**1. Continuous Internal Assessment** **(CIA) Internal Test** **Assignment –** Every student needs to write an assignment on a given topic based on the available published literature 2. **Seminar Presentation –** A topic needs to be presented and discussed with the class **3. Semester End Examination**

Learning Resources

1. Wahab, Mohammad Abdul. *Solid state physics: structure and properties of materials*. Alpha Science Int'l Ltd., 2005.
2. Omar, M. Ali. *Elementary solid-state physics: principles and applications*. Pearson Education India, 1999.
3. Callister, William D., and David G. Rethwisch. *Fundamentals of materials science and engineering*. Vol. 471660817. London: Wiley, 2000.
4. Krishnan, Kannan M. *Fundamentals and applications of magnetic materials*. Oxford University Press, 2016.

Relevance of Learning the course/ Employability of the course
Learning the physics of materials is crucial for understanding the fundamental properties and behaviour of different materials. This knowledge enables students to understand the development of advanced materials with specific electrical, optical, dielectric, and magnetic properties, which are essential for various technological applications. This course also equips students with a good theoretical foundation and insights needed to innovate and solve real-world engineering and scientific challenges. It bridges the gap between fundamental physics and material science, driving progress in multiple cutting-edge fields.

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	MAHATMA GANDHI UNIVERSITY **Graduate School**		
	4 + 1 Integrated UG and PG Programme		
School Name	**School of Energy Materials**		
Programme	**4 + 1 Integrated UG and PG Programme**		
Course Title	**Materials Chemistry**		
Course Type	**Minor**		
Course Level	**100-199**		
Course Code	**MG2DSCUEM141**		
Course Overview	In this course on chemistry of materials, we intend to introduce basic understanding of materials that has been used in today's technology. In the introductory module, students delve into the periodic table to understand the physical and chemical properties of elements, alongside exploring the structural intricacies of solids, crystalline imperfections, and the crucial structure-property relationship. The curriculum progresses to encompass systems of technological significance, including naturally occurring materials, optical and magnetic systems, and semiconductors, fostering an understanding of their synthesis, properties, and applications. Additionally, students explore diverse material synthesis methods, from solution-based approaches to solid-state and hybrid techniques, preparing them to engineer novel materials tailored to specific needs.		
Semester	**2**	**Credit**	**4**
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	45 Hours Teaching Hours	**30 Hours Practicum**	
Pre-requisite	The basic chemistry, familiarity with the periodic table, and introductory knowledge of solid-state chemistry concepts are required**.**		

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 physical and chemical properties of elements, the structural intricacies of solids, and analyze the significance of the structure-property relationship in materials chemistry	U, R	
2	To explore the synthesis, properties, and applications of naturally occurring materials, optical and magnetic systems, and semiconductors, fostering a comprehensive understanding of materials under technological significance	A	

3	To gain proficiency in diverse material synthesis methods, ranging from solution-based approaches to solid-state and hybrid techniques, enabling the engineering of novel materials tailored to specific applications.	An, E, S	
4	To investigate advanced materials such as biodegradable polymers, conducting polymers, composite materials, liquid crystal polymers, and nanomaterials, and evaluate their properties and diverse applications across various fields, including medicine, environmental science, and electronics.	I, An	
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module 1	**Hours**	**CO No.**
Introduction to Materials: Periodic table – physical and chemical properties of Elements; Structure of solids- description of unit cell and space lattices, Coordination number, APF for cubic and hexagonal close-packed structures, Miller indices, non-Crystalline structures properties of crystalline and amorphous structures, Crystal imperfections; Significance of structure-property relationship.	**10**	**1**
Module 2	**12**	**2**
Systems under Technological Importance: Naturally occurring materials; Optical and magnetic systems based on Metals; Inorganic semiconductors- Optical and magnetic materials; Organic semiconductors - Optoelectronic materials; Superconductivity - Application of High-Temperature Superconductivity.		
Module 3	**12**	**3**
Chemical and Non-Chemical approach to Material Synthesis Solution-based material synthesis-Precipitation methods, hydrothermal, etc., Solution based materials synthesis: Micro-emulsion, Sol-gel, Phase transfer reactions; Material synthesis using microwave radiation and ultra-sonic waves.		
Module 4	**11**	**4**
Advanced Materials Properties and applications-Biodegradable polymers-polylactic acid (PLA) and Polycaprolactone (PCL). Conducting polymers-polycetylene, polyaniline. Polypyrrole, Composite materials-introduction, general classification. Nanomaterials-Definition, nano scale. Carbon nano tubes (CNT) types and difference between Single wall NT, Multi wall NT; applications of nanomaterials in medicine, environment and electronics.		

Mode of Transaction	**Classroom activities** Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Mode of Assessment	**2. Continuous Internal Assessment (CIA)** **Internal Test** **Assignment –** Every student needs to write an assignment on a given topic based on the available published literature **2. Seminar Presentation –** A topic needs to be presented and discussed with the class **3. Semester End Examination**

Learning Resources

1. A.R. West, Solid-State Chemistry and its applications
2. D.M. Adams, Inorganic Solids
3. P.A. Cox, The electronic structure and chemistry of solids
4. R.C. Evans, An Introduction to crystal chemistry
5. N.N. Greenwood, Ionic crystal, lattice defect and non-stoichiometry
6. C. Kittel, Introduction to solid state physics
7. C.N.R. Rao and J. Gopalakrishnan, New directions in solid state chemistry

Relevance of Learning the course/ Employability of the course
The course is designed to introduce the various aspects of Materials Chemistry - Candidates desires to learn chemistry related aspects of materials would benefit from the course. The course also introduces many aspects from a fundamental understanding, which would be beneficial to the students who is pursuing studies on materials

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	MAHATMA GANDHI UNIVERSITY **Graduate School**		
	4 + 1 Integrated UG and PG Programme		
School Name	**School of Energy Materials**		
Programme	**4 + 1 Integrated UG and PG Programme**		
Course Title	**Fundamentals of Electrochemical Devices**		
Course Type	**MDC**		
Course Level	**100-199**		
Course Code	**MG2MDCUEM101**		
Course Overview	Energy is a fundamental issue facing society world-wide. Electrochemical devices play an important role in energy storage and conversion, especially at certain power-levels. Evolving renewable energy sources may have a critical dependence on electrochemical devices. The course is appropriate for students interested in the general topic of energy and more specifically electrochemical devices used to store or convert energy from one for to another.		
Semester	**2**	**Credit**	**3**
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	45 Hours Teaching Hours	**15 Hours Tutorial**	
Pre-requisite	This course has no prerequisites and can be taken by anyone.		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Students will be introduced to the principles and functioning of Electrode processes	U, R	
2	Gain knowledge of Electrochemical thermodynamics, kinetics, and transport phenomena.	U, An	

3	To be proficient in utilizing a variety of electrochemical techniques to analyze and interpret the behavior of electrochemical systems, enabling them to conduct advanced research and practical applications in the field.	A, E	
4	Understand the fundamental physicochemical mechanisms and interactions that underlie in electrodes in an energy storage and conversion system	C,S	
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module 1	Hours	CO No.
Introduction and Overview of Electrode processes: Electrochemical Cells and Reactions, Nature of Electrode-Solution Interface, Faradaic Reactions, Mass Transfer Controlled Reactions, Coupled Chemical Reactions	**8**	**1**
Module 2	**10**	**2**
Electrochemical Thermodynamics: Basics of Electrochemical Thermodynamics, Liquid Junction Potentials. Kinetics of Electrochemical Reactions: Arrhenius Equation, Transition state theory, Butler Volmer model, Marcus Theory.		
Module 3	**15**	**3**
Electrochemical Methods: Linear Sweep Voltammetry, Cyclic Voltammetry, Square wave Voltammetry, Chronoamperometry, Chronopotentiometry, Rotating Disk Electrode, Rotating Ring-disk Electrode, AC impedance, Spectro electrochemistry.		
Module 4	**12**	**4**
Applications of Electrochemistry: Electron Transfer, Characterization of Inorganic Complexes, Catalysis, Supercapacitors and Batteries.		

Mode of Transaction	**Classroom activities** ● **Class room lecture** ● **Visual presentation** ● **Discussion/ Brainstorming** **Field activities** **Lab based activities**
Mode of Assessment	**Continuous Internal Assessment (CIA)** **1. Internal Test** 2. **Assignment –** Every student needs to write an assignment on a given topic based on the available published literature 3. **Seminar Presentation –** A topic needs to be presented and discussed with the class **3. Semester End Examination**

Learning Resources

1. Electrochemical Methods: Fundamentals and Applications, Allen J Bard and Larry R. Faulkner, 2nd Edition, John Wiley and Sons
2. Modern Electrochemistry Ionics: Volume 1, John O'M. Bockris and Amulya K. N. Reddy, 2nd Edition, Plenum Press.

Relevance of Learning the course/ Employability of the course
A thorough understanding of electrochemical principles and techniques equips students with the skills necessary to innovate and improve devices like batteries, fuel cells, and biosensors. This expertise is highly sought after in industries focused on renewable energy, medical diagnostics, and electronic manufacturing. Additionally, the course enhances employability by preparing students for roles in research and development, quality control, and technical consulting, making them valuable assets in both industrial and academia. The knowledge gained from this course also provides a strong foundation for advanced studies and specialized careers in electrochemistry and related fields.

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	MAHATMA GANDHI UNIVERSITY **Graduate School**		
	4 + 1 Integrated UG and PG Programme		
School Name	**School of Energy Materials**		
Programme	**4 + 1 Integrated UG and PG Programme**		
Course Title	**Bio Energy**		
Course Type	**MDC**		
Course Level	**100-199**		
Course Code	**MG2MDCUEM102**		
Course Overview	Bioenergy is one of many diverse resources available to help meet our demand for energy. It is a form of renewable energy that is derived from recently living organic materials known as biomass, which can be used to produce transportation fuels, heat, electricity, and products. This course aims to develop fundamental inputs required to meet the challenges of a sustainable energy future. The bioenergy industry is undergoing rapid growth due to the policy drivers underpinning the current interest in bioenergy, such as energy security and climate change. This course adopts a whole systems approach and enables students to critically appraise the sustainability of various biomass energy production routes.		
Semester	**2**	**Credit**	**3**
Total Student Learning Time	**Instructional hours for theory**	**Instructional hours for practical/lab work/field work**	
	45 Hours Teaching Hours	**15 Hours Tutorial**	
Pre-requisite	This course has no prerequisites and can be taken by anyone.		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Learn how Energy is obtained from biomass sources and their conversion technologies.	U, R	
2	Classify gasifiers and understand their application.	U	

3	Explain the basic concepts of biomass technologies and generation of biofuels.	An, S	
4	Understand on anaerobic digestion and biomass combined heat and power.	U, A	
5	Design a bio-energy production system.	C, S	
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module 1	**Hours**	**CO No.**
Introduction: Biomass- types- Energy from Biomass-Sources-Conversion Technologies - Biogas Plants-Classification-Advantages and Disadvantages- Carbon neutrality.	**8**	**1**
Module 2	**10**	**2,3**
Methods for Energy From biomass -Thermal gasification- Classification of gasifiers- Application of gasifiers-Problems-Pyrolysis -Alternative liquid fuels. Combustion: Perfect, complete and incomplete, equivalence ratio, fixed Bed, fluid Bed, fuel and ash handling, steam cost comparison with conventional fuels.		
Module 3	**15**	**4**
Biomass technologies- Carbon cycle- Biofuels-Ethanol-bio diesel and green fuels-bio fuel from algae-Anaerobic digestion- Bio mass combined heat and power.		
Module 4	**12**	**5**
Bio-methanation: Microbial systems, phases in biogas production, possible feed stocks. Biogas plants, types, design, constructional details and comparison, biogas appliances, Burner, illumination and power generation, effect on engine performance		

Mode of Transaction	**Classroom** **activities Field** **activities** **Lab based activities**

Mode of Assessment	**Continuous Internal Assessment (CIA)** **1. Internal Test** **2. Assignment – Every student needs to write an assignment on a given topic based on the available published literature** **3. Seminar Presentation – A topic needs to be presented and discussed with the class** **3. Semester End Examination**

Learning Resources

1. Non-conventional energy sources; G. D. Rai, 2011, Fifth Edition, Khanna Publishers
2. Renewable energy systems, David M Buchla, Thomas E kissell, Thomas L Flyod
3. Bio Energy Technology Thermodynamics and costs. David Boyles, (1984), Ellis Hoknood Chichester
4. Biomass Gasification – Principles and Technology. Tom B Reed, (1981)
5. Biogas Technology – A Practical Handbook, Khandelwal, K.C, Mahdi, S.S. (1986) Tata McGraw Hill

Relevance of Learning the course/ Employability of the course
This course adopts a whole systems approach and enables students to critically appraise the sustainability of various biomass energy production routes. The module teaching and learning will comprise lectures and a site visit. The coursework requires students to either design a biofuel/bioenergy production system, or critically review a biofuel/bioenergy production process. The bioenergy industry is currently undergoing rapid growth.

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